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A journal of stomatology; devoted to the advancement and dissemination of knowledge pertaining to the teeth and mouth, and to their relations to the body as a whole

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Important Books Received

Local anesthesia simplified. By John Jacob Posner, D.D.S., Chief of the Dental Department, Harlem Dispensary, New York City. 1924: pp. 114; 7 x 4½ in; 55 illustrations; $3.50. C. V. Mosby Co., St. Louis.

Personal hygiene for nurses. By John Wymond Miller Bunker, Ph.D., Associate Professor of Biochemistry and Physiology, and Clair Elsmere Turner, M.A., C.P.H., Associate Professor of Biology and Public Health, Massachusetts Institute of Technology. 1924: pp. 189; 6 x 3½ in.; 6 illustrations; $2.00. C. V. Mosby Co., St. Louis.

Essentials of physiology, including the pharmacodynamics of the important typical drugs. By George Bachmann, M.S., M.D., Professor of Physiology, School of Medicine, Emory University, and A. Richard Bliss, Jr., A.M., Phm.D., M.D., Professor of Pharmacology and Director of the Departments of Pharmacology and Physiology, Colleges of Medicine and Dentistry and School of Pharmacy, University of Tennessee (Memphis). 1924: pp. 343; 8¼ x 5 in.; 178 illustrations; $4.00 net. P. Blakiston's Son and Co., Philadelphia.

Physiological and clinical chemistry. By William A. Pearson, Ph.C., Ph.D., M.D., Professor and Head of the Department of Chemistry, Physiological Chemistry, and Toxicology, and Joseph S. Hepburn, A.M., B.S. in Chem., M.S., Ph.D., Associate Professor of Chemistry, Hahnemann Medical College and Hospital, Philadelphia. 1925: pp. 306; 6¼ x 3¾ in.; 30 illustrations; $4.00. Lea and Febiger, Philadelphia.

Textbook of physiology. By William D. Zoethout, Ph.D., Professor of Physiology, Chicago College of Dental Surgery, Loyola University. *Second edition.* 1925: pp. 616; 6¾ x 4 in.; 186 illustrations, $4.50. C. V. Mosby Co., St. Louis.

Physiological Chemistry; textbook and manual for students. By Albert P. Mathews, Ph.D., Professor of Biochemistry, University of Cincinnati. *Fourth edition.* 1925: pp. 1233; 7¼ x 4½; 109 illustrations; $6.50. William Wood and Co., New York City.

Bacterial infection, with special reference to dental practice. By J. L. T. Appleton, Jr., B.S., D.D.S., Professor of Microbiology and Bacteriopathology, Thomas W. Evans Museum and Dental Institute School of Dentistry, University of Pennsylvania. 1925: pp. 474; 7¼ x 4 in.; 96 illustrations; $6.00. Lea and Febiger, Philadelphia.

Physical chemistry in biology and medicine. By J. F. McClendon, Ph.D., Professor of Physiologic Chemistry, and Grace Medes, Ph.D., Assistant Professor of Physiologic Chemistry, Medical School, University of Minnesota (Minneapolis). 1925: pp. 425: 6¾ x 4 in.; 34 illustrations; $4.50. W. B. Saunders Co., Philadelphia and London.

Dental materia medica and therapeutics, with special reference to the rational application of remedial measures to dental diseases. By Hermann Prinz, A.M., D.D.S., M.D., Sc.D., Professor of Materia Medica and Therapeutics, Thomas W. Evans Museum and Dental Institute School of Dentistry, University of Pennsylvania. *Sixth edition.* 1926: pp. 632; 7 x 4½ in.; 146 illustrations; $6.00. C. V. Mosby Co., St. Louis.

Technic of oral radiography. By Clarence O. Simpson, M.D., D.D.S., F.A.C.D. 1926: pp. 207; 6¾ x 4 inches; 165 illustrations; $5.00. C. V. Mosby Co., St. Louis.

Orthodontics: an historical review of its origin and evolution. *Two volumes.* By Bernhard Wolf Weinberger, D.D.S., Librarian of First District Dental Society of the State of New York, and Advisory Librarian, Dental Department, New York Academy of Medicine, New York City. 1926: pp. 1011; 7¼ x 4½ in.; 599 illustrations; $25.00 *(two volumes)*. C. V. Mosby Co. St. Louis.

A textbook of exodontia—exodontia, oral surgery, and anesthesia. Leo Winter, D.D.S., Professor of Oral Surgery, College of Dentistry, New York University. 1927: pp. 364; 7½ x 4½ in.; 329 illustrations; $7.50. C. V. Mosby Co., St. Louis

Harelip and cleft palate (cheiloschisis, uranoschisis, and staphyloschisis). By Matthew N. Federspiel, B.Sc., D.D.S., M.D., F.A.C.S., Professor of Oral Surgery, Marquette University. 1927: pp. 200; 6¾ x 4 in.; 156 illustrations; $5.00. C. V. Mosby Co., St. Louis.

A text-book of bacteriology for dental students. By Arthur Bulleid, L.R.C.P. (London), M.R.C.S., L.D.S. (England), Assistant Dental Surgeon and Assistant Bacteriologist, Guy's Hospital, London. 1927: pp. 219; 6¾ x 4 in.; 60 illustrations; $4.50. C. V. Mosby Co., St. Louis.

THE PLACE OF DENTISTRY IN A PUBLIC HEALTH PROGRAM[1]

LOUIS I. HARRIS, M.D.

Commissioner of Health of the City of New York

I have no set speech to offer. I have been invited to speak briefly. I shall attempt to be brief and lay before you plans, not well developed as yet, for the conduct of the activities of the Health Department insofar as they concern the dental service. More particularly I shall speak of these plans as they concern the dental care of the members of the community for whom it is proper that the Health Department should be concerned. The adoption of a specific program can come only after consultation with members of your profession; so it is impossible to announce a fully developed plan as yet. However, I have some thoughts that I shall attempt to present to you, and that I think will be best presented from the broad viewpoint of the public health situation, and the public health problem as it exists today. I say "today" advisedly, because the public health situation is in a state of flux, of evolution, of development.

Viewing the problem very broadly, and not losing one's self in details, one may present the public health field as analogous in many ways to a line of battle. As we visualize the battle front, and follow it from the point of view of age grouping, we might begin at one extreme with that concentration of effort —on that particular salient—which has to do with the prevention of infant mortality. As a matter of fact, the effort goes back farther, and is so locked up with the question of maternal welfare, that we must speak of these two things as one. Maternity, or pre-natal work, and child welfare work are closely linked, not only because of our sentimental regard for the lives of children, but also because, if we begin with the earliest age group and plan

[1] Stenographic report of an address at a meeting of the First District Dental Society of the State of New York, at the New York Academy of Medicine, February 1, 1926, shortly after Dr. Harris became Commissioner of Health of New York City.—(*Ed.*)

wisely, we will not have such a tremendous problem presenting itself to us in the later age groups. There will inure a certain benefit in the later age groups, and for that reason we have been justified in emphasizing pre-natal and child welfare work. The pre-natal work has to do with the welfare of the mother. The dental profession is interested in that. Present day study has shown that dental pathology may have its origin in conditions that should be treated along preventive lines during the period of pregnancy, and that such treatment will greatly benefit both the mother and the child.

Then as we march along the battle line, we come to the next age group—those who are two to five years of age. At one end we have our program of pre-natal and infant welfare work, and then there is a gap so far as the two- to five-year age group is concerned. Instead of having rallied our forces to assert our power against the menacing forces that threaten this age group, we make a very poor showing, for there is no organized work for the child of pre-school age. I am not ascribing blame to any one agency or group of agencies. There are casual attempts to deal with this problem here and there, but they represent no such well organized machinery as we find in the infant welfare work, and as we will find when we consider the next age group, the child of school age. There again we have concentrated our fire, and there has been a very measurable degree of success. Much remains to be done, for we have failed to benefit by lessons that we might with profit have learned through a close scrutiny of the work of other communities. We may transplant the efforts of other communities into our own without sacrifice or loss. That comparison involves no disparagement of those who have labored in this field, but it is well that we take stock honestly.

When we come to the adolescent group, our machinery becomes halting and painful. I mean on the public health side—I am not talking of dentists or others. The adolescent group has received a little attention recently, by reason of the fact that there are laws on our books which say that because the child which enters industry may be subjected to a variety of hazards, it is to be protected from them in some measure at least. But I will not dwell on that here.

As to adults, we hear more and more of periodic health examinations. We have had such examinations, after a fashion and of a kind, insofar as school children are concerned.

Why do I take stock of this battle line? You cannot plan public health work, nor sit down with your friends and confer profitably with them, unless you do envisage the entire problem. Some say venereal diseases are paramount, and if we were to hearken to those individuals, we would make that our major if not our principal activity. There are some who clamor for an attack upon the so-called degenerative diseases—cardiac, renal and other diseases. Then the group interested in cancer din their views into our ears—as they should and must—and their plea must be listened to with considerable interest and intelligence, and be incorporated, so far as can be, into the general scheme of things. Then the mental hygienist, and a host of others, who each have a special plea—and the dental profession, and the dental hygienist come in due time to ask for a measure of attention.

I am not here to flatter you. I flatter you best when I take you into my confidence and treat you as the scientific men and women that you are; but I do not see dentistry as the alpha and omega of public health work. No, I say that the contribution that dentistry can make to public health is a contribution that concerns various parts of this battle line which I have tried to visualize for you. I see that contribution as a valuable one, but in due proportion. A peculiar thing about public health is that the major and minor questions vary in importance from year to year—almost from month to month. Today my attention is directed with greatest intensity to a question which may not seem a profoundly moving and stirring one—the abating of the smoke nuisance. I just want to indicate the need for a sense of proportion in evaluating each of these subjects and apply the principle to a consideration of the place of dental hygiene in our health program.

I am stirred very much by the milk situation. My education is progressing apace, and I am learning a great deal of the major and minor iniquities that have developed. I am not here to be the devil's advocate, or anyone else's—but I am learning that milk holds a great deal to interest us. Pasteurization does not always mean security. The composition of cream is not a thing to conjure up stirring images, or set men's hearts aflutter, but in its time and place it is of importance. When you realize that the milk and cream that is being tabooed because it is not fit to be used, is manufactured into cream

cheese, you can see that this is a matter to be taken seriously under consideration. Today it is a subject of importance. Tomorrow it may be something else—but, being human and therefore frail, and incapable of taking in at once all phases of the problem, I pass from one to another.

Dentistry must take its proper place in due season in the scheme of public health work. There are many questions which I might approach tonight, which must remain moot questions. So when I come to name, with your permission and your consent, an advisory board, I may sit with them and talk things over with them without having a program already made, and without having a steam roller at hand with which to put a specific program into effect.

Where are the limitations in health work to be put?. These are questions which I shall address in due season to this advisory board. How many dental hygienists do we need? For whom shall we supply them? Why shall we supply them only to children? Why not to adults? Why not take care of the teeth of tubercular individuals who are to enter sanatoria? What shall we do with the great class of children for whom we are caring in our pre-tuberculosis activities?

What about our contagious disease hospitals? We have from time to time given them emergency service, but I am not satisfied that that is the right service, or that we follow our hospital cases through when they recover. When there is an infectious disease which has laid low the individual for the time being, we are not finished with our job—as I construe the public health obligations that devolve upon us—when we discharge the case from the hospital. I mean specifically our cases of measles or scarlet fever or diphtheria. We followed through 850 scarlet fever cases recently, and discovered that when the doctor had finally acquitted himself of further responsibility for the care of a patient, and the family were in varying degrees of glee over the recovery, a subsequent examination showed cardiac affections and renal affections that had not been noticed, or perhaps were not present when the case was dismissed.

I can only attempt to indicate a few things. I am firmly convinced that whether we have a Bureau of Dental Hygiene and Dentistry, or whether we merely perform this function in a thorough manner by whatever name it is called—that the Bureau of Hospitals and the

Bureau of Preventable Diseases and the Bureau of Child Hygiene must receive their due meed of dental hygienic service.

Up to now, I have been talking only of this matter from the public health view. I made a provisional promise to you, a few weeks ago at your dinner which I attended, when I had no knowledge that the crown was to rest with more or less grace on my head. I spoke of myself as the mouthpiece or spokesman for all agencies concerned in the propoganda for general hygiene in the community. Now I am in the position, which may be uncomfortable or comfortable—depending upon my honesty and my intentions—of having to make good my promise. I desire not only your coöperation, but I desire to give what service I can to make my voice, so far as it can reach effectively, an instrument which is yours to command. I am sure you will want to command me to use that instrument in only the best of causes, and these we will have our advisory board thresh out. We will not always agree. I cannot accept all your program ready-made, nor will you accept mine. We will perhaps not convince the skeptical group of people who wish to usher in a Utopia at once; but we will, with our attempt at coöperation, do much to accelerate and stimulate public health work, and public health enterprise so far as it pertains to dental hygiene. We shall have to mark out the scope of our work, and what we expect to do—possibly to make a budget.

I have noted with great amusement, although it has a tragic side, that there is a budget appropriation for the appointment of eight dental hygienists; and yet when we come to appoint them, there is no place into which to fit them. However, we are not going to be balked by that. We will not solve the problem all at once, but I have the comforting assurance that the Mayor is anxious to see public health come through as an ornament of his administration. When I met him for the first time on December 31, the clarity with which he spoke of public health and the police problem, as two things upon which he would rest his reputation, made me feel sure that I would have a free hand, and would not be instructed, except to do what is right—that I would not be thwarted or obstructed, and that he meant what he said. And with that promise to the medical and dental professions, and those allied in the public health work, we are indeed encouraged that we may go on to plan our work. I have a notion that a proper

approach to the Mayor and the Board of Appropriation will yield us the proper amount—after we have determined what that is—to press this work as fast as is wise.

I have a consciousness that I have been talking to you in a rambling way, but anyone would talk in a rambling way if he made as many speeches as I do upon these various things. I have discussed coöperation, and I must say I am not paying lip tribute to it only, but I have it in mind that I at least mean to try to do the right thing with you in the way of coöperation. I hope my little introductory bow tonight, my attempt to speak to you and perhaps to be seen by the dental profession and measured as to my sincerity, fulfills a certain mission. I want to assure you that I mean truly and honestly and as actively as I can, to counsel and coöperate with you in doing what I ought to do as your mouthpiece and spokesman. On the other hand, I expect you, although differences may arise, to give me the benefit of your mature judgment and your wisdom, to the end that our planning of a program may balance, that there may be poise and sanity in what we will attempt to do.

I am extremely grateful to be able to appear before you and to make this gesture of friendship to you.

MEDICO-DENTAL CASE RECORDS: SECOND REPORT[1]

A Clinico-pathological Study

BISSELL B. PALMER, JR., D.D.S., and MALCOLM W. CARR, D.D.S.

New York City

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I. Introduction

It was stated in an earlier paper[2] that one of the objects in publishing these medico-dental case reports is to stimulate the interest of the dental practitioner in medical topics and terminology, and to arouse the interest of the medical practitioner in dental procedures and nomenclature. Although this case, because of the advanced age of the patient, the possible existence of another focus of infection, and the chronicity of the symptoms, is not ideal for inclusion in the proposed compilation, it was selected for publication for two reasons: because oral sepsis was a contributing factor in the patient's general condition; and it is an exceedingly interesting case of pernicious anemia from

[1] The first report was published in the *Journal of Dental Research*, 1926, vi, p. 283.
[2] Palmer and Carr: *Journal of Dental Research*, 1926, vi, p. 271.

which much of value may be learned in medical terminology and procedure.

II. Case B-1 (1):[3] Pernicious Anemia (2)

FIRST ADMISSION

General history and physical examination

On June 3, 1923, a retired business man, sixty-nine years of age, entered the hospital[4] complaining of diarrhea and fatigability. The family history (3) was negative. His mother was living and in good health at 97 years of age. His father died of typhoid fever. As a child, the patient had scarlet fever, measles, influenza, parotitis, and tuberculosis. Twenty years previous to this admission he had severe diarrhea, with the passage of profuse watery stool once daily. Fifteen years ago he had severe pain in the right upper quadrant (4), believed to be cholecystitis (5), followed by an attack of jaundice (6); three years ago, he had pneumonia. In 1921, a roentgenographic examination of the chest eliminated the possibility of active pulmonary tuberculosis.

When he entered the hospital, there was no abdominal pain, no blood in the stools (7), and neither nausea nor vomiting, but there had been a return of the diarrhea (8). The patient had always been frail, and had grown progressively weaker and paler for the last few years. The appetite had always been poor. About six weeks before admission, fatigue developed easily, he became exceedingly weak, and it was necessary for him to remain in the house. His weight had dropped to 126 pounds. His average weight had been 140 pounds; his best weight, 157 pounds.

Examination showed a fairly well developed and nourished (9) man, not appearing acutely ill. The skin was pale with a yellow-greenish tint, and there was extreme pallor of the conjunctivae, lips, and mucous membranes. There were no organic murmurs of the heart (11). The systolic blood pressure (12) was 110 mm.; the diastolic (13), 70 mm. Auscultation of the chest elicited no râles (14). The

[3] The numerals in parenthesis refer to the numbered items in "Notes and comment," on page 121.

[4] The Fifth Avenue Hospital, New York City.

liver was slightly enlarged (15); the spleen was not palpable (16), and the extremities were not edematous (17).

Laboratory and miscellaneous data

The temperature, pulse, and respiration were recorded within the limits of normal variation.

Urinalysis (18). Amount, normal; specific gravity, 1.031; reaction, acid; albumin, very faint trace; sugar and casts, absent; indican, positive. *Microscopic examination:* red cells, absent; white cells, few; epithelial cells, few.

Blood examination (19). *June 4, 1923:* hemoglobin, 50 per cent; red cells, 1,600,000; white cells, 5,600; polymorphonuclear leucocytes, 40 per cent; lymphocytes, 56 per cent; eosinophiles, 4 per cent. *June 6, 1923:* hemoglobin, 45 per cent; red cells, 1,600,000; white cells, 4,600; polymorphonuclear leukocytes, 32 per cent; lymphocytes, 66 per cent; eosinophiles, 2 per cent; hemoglobin index, 1.4. *Blood chemistry* (20)—mg. per 100 cc.: urea nitrogen, 11.3; creatinin, 0.8; uric acid, 2.5; sugar, 102; CO_2, 54 per cent; Wassermann reaction, negative. *Blood culture* (21): negative.

Stool examination (22). "Occult blood not found. Ova and parasites not identified."

Roentgenographic examination. "A series of plates taken in the standing posture show no evidence of organic lesion of the stomach" (23).

Diagnosis. Pernicious anemia.

The patient improved slightly under medical treatment, and was discharged from the hospital on June 8, 1923, five days after admission.

SECOND ADMISSION

General history and physical examination

On February 26, 1924, eight months after the first admission, the patient re-entered the hospital for the treatment of pernicious anemia, and particularly for the elimination of the oral foci of infection.

The slight improvement in the patient's general condition, following the discharge from the hospital in June, 1923, was only temporary. Although the diarrhea had become less severe, there had been a con-

tinuation of fatigability and indisposition to exertion. The muscular weakness had increased, and palpitation (24) and dyspnoea (25) became manifest upon slight exertion. Occasionally there had been an uncomfortable feeling of faintness (26). For the past four months the patient had considerable nausea, accompanied by frequent vomiting (27). Gnawing pain in the epigastrium (28) had recently developed, and anorexia (29) and diarrhea had continued. For many months there had been a complete loss of the sense of taste (30). For some time sodium cacodylate (31) had been administered. On February 19th there had been a blood transfusion (32) at the patient's home.

Physical examination at the time of admission failed to disclose any marked change from the findings recorded at the time of the first admission.

Report of the dental consultant

Oral examination. "Oral examination reveals an advanced chronic suppurative pericementitis (33), which is manifested in the periodontal tissues surrounding the remaining teeth. There is a moderate deposition of salivary calculus, an excessive alveolar absorption, and presence of pus. Several teeth are missing, dental caries is absent, and the oral hygiene is poor."

Roentgenographic examination. "Roentgenograms show no evidence of periapical (34) infection due to pulpless teeth."

Comment. "The oral condition may be an important contributing factor in this patient's general condition."

Recommendations. "Advise the removal of all the remaining teeth, except the lower cuspids, in several stages (35). Procain-suprarenin solution (1 per cent) is the anesthetic of choice. The removal of the teeth may probably be accomplished in three operations, so spaced as to prevent any accumulative reaction to toxic absorption."

Laboratory and miscellaneous data

The temperature, pulse, and respiration were recorded within the limits of normal variation.

Urinalysis. Amount, normal; specific gravity, 1.022; reaction, acid; albumin, sugar, casts, and indican, absent. *Microscopic examination:* red cells, absent; white cells and epithelia, few.

Blood examination. February 27th (36), the day following the second admission: hemoglobin, 34 per cent; red cells, 1,750,000; white cells, 4,000; polymorphonuclear leukocytes, 61 per cent; lymphocytes, 39 per cent; hemoglobin index, 1. *Microscopic examination* of the blood cells showed marked anisocytosis (37), poikilocytosis (38), polychromatophilia (39), and achromia (40). (See tabulation of blood cells, page 120, for comparison following oral surgical treatment.)

Report of the Pathologist. "This is a severe secondary anemia of the type that approaches pernicious anemia. Anisocytosis and poikilocytosis present. No nucleated cells nor other abnormal cells. The hemoglobin index is indicative of pernicious anemia."

Treatment and operations

Medical treatment. The medical treatment instituted within the time of this study was proper diet, rest, and elimination. Sedatives to reduce pain, nux vomica as an alterative (41), and sodium cacodylate, were the only drugs administered.

Oral surgical treatment. The teeth were removed in three operations, with the patient in bed in a semi-supine posture. The local anesthetic was 1 per cent solution of procain containing epinephrin, 1–40,000.

At the first operation, on February 27th, three teeth were removed and the sockets lightly curetted, 5 cc. of the anesthetic solution having been employed. At the second operation, on March 4th, three teeth were removed and the sockets lightly curetted; 7 cc. of the anesthetic solution were used. At the third operation, on March 11th, five teeth were removed, and the sockets curetted; 7 cc. of the anesthetic solution were employed. The advanced periodontal (42) infection had caused almost complete destruction of the alveolar process surrounding all these teeth, and much pathological granulation tissue had developed. Due to the congestion, profuse bleeding (43) followed the removal of the teeth at the third operation, which, however, was soon controlled.

Cultures were taken from the apices of the roots of two of the teeth and both cultures were reported positive for Streptococcus viridans. No vaccine was prepared.

No unfavorable reactions were observed following the injection of the anesthetic, nor exacerbations (44) after the operations.

Summary of blood examinations

1923	Hgb. Per cent	R.B.C.	W.B.C.	Poly.	Lymph.	Eosin.
June 4	50	1,600,000	5,600	40	56	4
June 6	45	1,600,000	4,600	32	66	2
1924						
Feb. 27	34	1,750,000	4,000	61	39	.
Feb. 28	41	2,100,000	.....	..	..	.
Mar. 4	42	1,900,000	.....	..	..	.
Mar. 7	43	2,100,000	7,800	54	46	.
Mar. 11	41	1,850,000	5,900	50	47	2

The patient was discharged from the hospital, "improved," on March 13th, 1924.

FOLLOW-UP RECORD

The patient returned home after his discharge from the hospital, March 13th. There was considerable improvement in his general condition. There was a complete return of the sense of taste, and his appetite was greatly improved. He felt much stronger, was able to walk without assistance, and the symptoms of nausea and vomiting disappeared. He carried on some literary work, but was confined indoors most of the time. A blood count made on March 19th showed that the hemoglobin increased to 49 per cent from 41 per cent on March 11th. The number of red cells increased to 2,190,000 from 1,850,000 on March 11th, and the white cells decreased to 5,680. The increase in the number of red cells and the upward trend in the hemoglobin percentage, as well as the improvement in the general subjective symptoms following the eradication of oral sepsis, made the prognosis seem a little more favorable. While it was not thought that he would be entirely relieved of his symptoms, it was hoped that he would be more comfortable and that his life might be extended. However, the improvement was not sustained. On May 22nd, he was again given a blood transfusion, and in June he suffered a relapse,

with an exaggerated return of all his old symptoms. He failed rapidly, and died June 30, 1924.

III. General Summary

This is a case of advanced pernicious anemia complicated by extensive oral sepsis. There was not only toxic absorption from the teeth but also a continuous free-pus discharge. The history indicates that the gall-bladder also might have been a focus of infection.

It is interesting that the blood transfusion on February 19th did not produce an appreciable improvement in the blood picture, such as appeared later following the elimination of oral sepsis. The hemoglobin percentage changed from 34 per cent, on February 27th, to 49 per cent on March 19th, a week after the removal of the last of the infected teeth. Within the same period of time, the red cells increased in number from 1,750,000 to 2,190,000 per cmm. Other indications that a remission (45) had occurred were a return of the sense of taste, return of appetite, cessation of nausea, and a definite increase in physical strength.

IV. Conclusion

In view of the fact that pernicious anemia is a disease attended by possible remissions, and that these remissions give an extension of life to the patient, and as remissions in this disease may be brought about by raising the resistance of the patient, and as this can be done by eliminating *contributing* infections, it seems a logical conclusion that in these cases all focal infections should be eradicated as early as possible.

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V. Notes and Comment

Explanatory and supplementary

(It seems justifiable to include in this section elementary terminology of both medicine and dentistry, as the medical notes may be of value to some of the dental profession, and the dental notes may be of interest to some of the medical profession.)

(1) Case B-1. As these cases are reported, they will be classified according to the diseases of the various organs and systems. Thus, the symbol B, represents the group of diseases that alter the condition of the *blood.*

(2) Pernicious anemia. A recurring and usually fatal general anemia caused by hemolytic agents. The exact cause remains obscure, and the nature and origin of the hemolysins are unknown; oral sepsis and intestinal infection have been suggested, but undoubtedly there are other unrecognized factors. Attention has been directed to the similarity of this disease to protozoal infection. It is a disease of middle life, and occurs in cases in which there has been no previous loss of blood, no chlorosis, no purpura, and no renal, splenic, glandular or malignant disease.

Addison, who first described the disease, gave the following indications of the symptomatology:

> "It makes its approach in so slow and insidious a manner that the patient can hardly fix a date to the earliest feeling of that languor which is shortly to become so extreme. The countenance gets pale, the whites of the eyes become pearly, the general frame flabby rather than wasted, the pulse perhaps large but remarkably soft and compressible, and occasionally with a slight jerk under the slightest excitement. There is an increasing indisposition to exertion, with an uncomfortable feeling of faintness and breathlessness in attempting it; the whole surface of the body presents a blanched, smooth, and waxy appearance; the lips, gums, and tongue seem bloodless, the flabbiness of solids increases, the appetite fails, extreme languor and faintness supervene, breathlessness and palpitation are produced by the most trifling emotion or exertion; some slight edema is probably perceived about the ankles; the debility becomes extreme—the patient can no longer rise from bed; the mind occasionally wanders; he falls into a prostrate and half-torpid state, and at length expires; nevertheless, to the very last, and after a sickness of several months' duration, the bulkiness of the general frame and the amount of obesity often present a most striking contrast to the failure and exhaustion observable in every other respect."

In pernicious anemia the total quantity of blood and the number of red cells are greatly diminished. The average count given by Osler is 1,575,000 per cmm. The hemoglobin is reduced, and the hemoglobin index is 1 or over. An important feature is the marked irregularity in size and shape of the red cells, with many large forms (macrocytes). The leukocytes are generally reduced in number (2000–4000). There is often a definite increase in the small mononuclear forms. The disease may run an acute course, but as a rule it is a chronic malady with remarkable remissions. The ultimate prognosis is bad in the majority of cases.

(3) Family history. Important in its relation to predisposition to disease.

(4) Right upper quadrant. This is the area of the abdomen over the right lobe of the liver with the gall bladder. Other structures within this

region are the hepatic flexure and the proximal portion of the transverse colon, the pylorus, head of the pancreas, portions of the duodenum, and the upper half of the right kidney.

(5) Cholecystitis. Inflammation of the gall-bladder.

(6) Jaundice. A condition characterized by coloration of the skin, mucous membranes, and fluids of the body by bile pigment.

(7) Blood in stools. The presence of a minute quantity of blood in the stools is a diagnostic factor of importance in cases of gastric ulcer, and gastric or intestinal malignancy.

(8) Diarrhea. This condition is frequently a symptom of profound anemia.

(9) Well developed and nourished. This is a factor of importance in the differential diagnosis between pernicious anemia and secondary anemia. In the former condition the patient may appear bulky and obese, whereas secondary anemia is produced by a *primary* devastating disease which causes emaciation.

(10) Extreme pallor. This condition, in pernicious anemia, is due to the low percentage of hemoglobin in the blood.

(11) Organic heart murmurs. While no organic heart murmurs were elicited, the usual functional murmurs common to pernicious anemia were heard. These murmurs may be attributed to excessive fluidity of the blood incident to anemia.

(12) Systolic blood pressure. This is the pressure of the blood during ventricular contraction.

(13) Diastolic blood pressure. This is the pressure of the blood during ventricular relaxation.

(14) Râles. This term is applied to adventitious sounds which are generated in the pulmonary tract. These sounds are caused by the pressure of serum, mucus, pus, or blood in the air passages, interfering with the free ingress and egress of air.

(15) Enlargement of the liver. In the normal adult subject, the inferior border of the liver will not be encountered below the costal margin. Obstruction of the common bile duct is one of the causes of enlargement of the liver.

(16) Spleen not palpable. The spleen is not palpable in a normal adult, with the normal spleen occupying its normal position beneath the left vault of the diaphragm.

(17) Edema. This is an abnormal accumulation of clear watery fluid in the lymph spaces of the tissues. Edema, usually affecting the feet, although sometimes the hands, is a common symptom in pernicious anemia. However, this condition was not manifest in the present case.

(18) Urinalysis. This urinalysis is practically normal, with the exception of the presence of a very faint trace of albumin and a slightly elevated specific gravity.

(19) Blood examination. Blood normally contains the following cellular elements: red cells, 5,000,000 per cmm.; white cells, 7,500 per cmm. The leukocytes are mainly differentiated into (1) polymorphonuclear neutrophylic leukocytes, 60–70 per cent; (2) lymphocytes, 25–33 per cent; endotheliocytes, eosinophylic leukocytes, and basophilic leukocytes are found in small numbers in normal blood. The hemoglobin index is the numerical expression that indicates the amount of hemoglobin in each red corpuscle.

(20) Blood chemistry. Blood normally contains certain chemical constituents which are of diagnostic importance in problems of metabolism and excretion. The waste products, urea, uric acid, and creatinin are of chief importance from the clinical point of view. The amounts present in the blood in health are as follows (mg. per 100 cc.): Total non-protein nitrogen, 25–30; urea nitrogen, 12–15; uric acid, 2–3; creatinin, 1–2. Higher figures are usually referable to accumulation of the respective substances in the blood because of defective elimination. In health, each 100 cc. of blood contains about 100 mg. of sugar, chiefly glucose.

(21) Blood culture. This is a procedure to ascertain the possible presence of living bacteria in the blood. The specimen for examination consists of 10–20 cc. of blood withdrawn from a vein by a sterile needle.

(22) Stool examination. The examination of feces is of importance in cases in which it is suspected that parasitical growths or protozoal infections occur in the intestines. The feces are examined by chemical analysis for occult blood in cases of suspected gastric ulcer or malignancy in the gastrointestinal tract.

(23) Organic lesions of the stomach. In cases of "gnawing pain" in the epigastrium, gastric ulcer is suspected. The roentgenographic examination was made for the purpose of determining the possible presence of such a lesion.

(24) Palpitation. Conscious pulsation of the heart. This is a common symptom of pernicious anemia, especially with a dilated heart.

(25) Dyspnoea. Dyspnoea, in this case, refers to a shortness of breath rather than to difficult or labored breathing. The patient's impression of shortness of breath is a *conscious* quickening of the inspiratory movements to supply a conscious need of air. In pernicious anemia, this is due to a diminished supply of oxygen, resulting from the inability of the red corpuscles to carry a sufficient charge.

(26) Faintness. Not an uncommon symptom in pernicious anemia. This might be due to low blood pressure, and the defective nutrition of the central nuclei, resulting from the decrease in the percentage of hemoglobin.

(27) Vomiting. Vomiting and other gastric signs, simulating gastric ulcer, are frequently symptoms of pernicious anemia. The vomiting may be due to anemic dilatation of the heart, but in this case it is believed to be related to the oral sepsis and the quantity of pus that was continually being swallowed.

(28) Gnawing pain in the epigastrium. While this is a symptom of gastric ulcer, paroxysms of pain in the stomach may occur in pernicious anemia.

(29) Anorexia. A loss of appetite.

(30) Sense of taste. In pernicious anemia there is often an atrophy of the papillae of the tongue. As the taste buds may become affected by the same process, it might be considered that loss of the sense of taste in this case was a symptom of the pernicious anemia. However, the fact that the sense of taste returned, following the removal of the septic teeth, indicates that the impaired function was due to the constant presence of pus in the mouth.

(31) Sodium cacodylate. An organic compound of arsenic, administered in the treatment of anemia. Small quantities of the arsenic are slowly set free in the tissues and act as an alterative.

(32) Blood transfusion. This term signifies the transfer of blood from one person to another—500 to 600 cc. is the usual amount transfused. Blood serum of one person may cause the agglutination of the blood cells of another person. This agglutination produces immediately serious effects and nullifies the beneficial influence of the transfusion. It has been found that the blood may be classified into four groups, and that blood of each group is compatible with other blood of the same group. Therefore it is necessary to "type" the blood of the donor and the recipient, before transfusion, to avoid the possibility of agglutination.

(33) Chronic suppurative pericementitis (periodontoclasia). A disease process that produces a breaking down of the tissue supporting the teeth.

(34) Periapical. Relating to the region surrounding the apices of the roots of the teeth.

(35) Stage operation. In order to avoid the sudden augmentation of the general absorption of toxins, which may result from the removal of many infected teeth at one operation, it is advisable to perform the removal of the teeth in several stages.

(36) February 27th. This blood count was taken one week following the transfusion.

(37) Anisocytosis. A lack of uniformity in the size of red blood cells. The condition is present in pernicious anemia.

(38) Poikilocytosis. The occurrence of red blood corpuscles of irregular shape commonly observed in pernicious anemia.

(39) Polychromatophilia. A tendency of certain cells, such as the red blood cells in pernicious anemia, to take both basic and acid stains.

(40) Achromia. Absence of the natural pigmentation in the red blood cells, due to deficiency of the hemoglobin.

(41) Alterative. A remedy, such as arsenic or iron, the action of which is to correct disordered metabolic processes and promote repair.

(42) Periodontal. Relating to the supporting tissues surrounding the teeth.

(43) Bleeding. There is a tendency to post-operative bleeding in cases of pernicious anemia, due to the increased fluidity of the blood and variation from normal of those chemical constituents in the blood that control clotting.

(44) Exacerbation. An increase in the severity of a disease or its symptoms.

(45) Remission. A lessening in severity; a temporary abatement of the symptoms of a disease.

SOME FUNDAMENTAL FACTORS IN THE CONSTRUCTION OF EFFICIENT DENTURES[1]

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A new era, comparable to the one which began with Bonwill, had its beginning with the publication of Dr. Gysi's articles on "The Problems of Articulation," in the *Dental Cosmos* of 1910. Added impetus was given the study of denture construction when, in 1913, he visited New York City and enabled teachers and students from widely distributed points in the United States and Canada to do practical work under his supervision. Since that time no one has successfully controverted the theory of the factors which he enunciated as essential to the construction of an efficient denture.

Many men with laudable enthusiasm and scientific trend of mind have swept the student dentist off his course with theories based on assumptions or, if you please, truths, which have proved valid in innumerable instances but which are inadequate and too arbitrary where conditions do not approach the average case. This is not to be regretted, since invaluable contributions have been made, and the dentist with his new articulator—his new plaything—took a renewed interest in the entire procedure of constructing dentures. These endeavors of inventor and disciple served to establish more firmly the true principles, and aided in developing a technique which has improved the old method of adapting the articulator to the individual requirements. In this process of development he has learned among other things to approach his patients with the consummate skill of a practical psychologist and thereby secure an indispensable factor, namely, the coöperation of the patient. With this coöperation he is able to supply successful masticatory substitutes because he enables the patient to realize the conditions required for the successful wearing

[1] Read at a meeting of the First District Dental Society of the State of New York, New York Academy of Medicine, December 2, 1925.

of dentures. And the further from the ideal the conditions may be in a given case, the more necessary is this realization by the patient. The dentist may now easily and properly shift to the patient the burden of mastering the use of his new dentures.

The dentist assumes full responsibility for construction. If he makes use of study casts, and facial outline data, and is convinced of the real merits of immediate dentures of occlusal rests,[2] the co-operation of the oral surgeon is necessitated. The question as to the extent of the operation is purely an academic one. In a particular case, the surgeon guided, *first*, by the condition of the teeth and areas surrounding them, will remove all obvious areas of infection and not unduly concern himself about possible intangible infected areas. *Second*, guided by the requirements of the prosthetist, he will trim the ridges in such a manner as to enhance esthetics, obliterate undercuts, and make it possible to place the artificial teeth properly in accordance with the physical demands of retention.

The patient supplied immediately with a denture or occlusal rest begins at once to grow accustomed to wearing bases. In addition to this advantage—which in itself justifies the construction either of dentures or of rests—the wounds are bandaged, hemorrhage is checked, the patient's jaws are rested in the correct habitual occlusal relationship, and he is afforded a relief from the unnatural feeling that accompanies the loss of his teeth. This in turn gives him a satisfaction which promotes the assurance of greater benefit to be derived from wearing properly constructed artificial dentures.

Two evenings might profitably be devoted to the subject of impression taking, and you may do this by reviewing Dr. Claude J. Stansbery's paper on maxillary impressions published in *The Journal of the American Dental Association*, April 1925, p. 438, and the article by Dr. F. Marlin Hight, in the same Journal, on mandibular impressions, July 1925, p. 778. I subscribe to the principles and technique employed by these skilled operators, and am convinced that the greatest single factor in securing a desirable impression is the improvised individual tray. This may appear trite, but from the prosthetist's standpoint it needs emphasis.

[2] By "*occlusal rest*," as used in this paper, is meant a base resting on the edentulous ridge, by means of which occlusal contact with the opposing jaw is provided.—[*Ed.*]

I have no quarrel with the expert operator who prefers that all impressions be secured with modelling compound, but I warn the novice that atmospheric pressure, as a factor in retention of dentures, is of secondary importance to adhesion; and that there is an evident lack of appreciation of the psychology involved where the operator unwittingly enters a contest with the patient to test his or her ability to dislodge the impression by a series of facial grimaces or muscular contortions. The advanced operator in compound secures the proper height of the labial and buccal flanges of his impression by massaging the borders at the proper temperature through the lips and cheeks, or by boldy trimming with a knife to meet the requirements. The sole object in this manipulation is to effect a valve seal. By valve seal I do not mean to suggest a constriction of the tissue adjacent to this peripheral border any more than of the tissues overlying the palatine formina. If the latter occurs, the blood and nerve supply are shut off resulting in a complaint from the patient of a hot burning sensation, which many believe to be the beginning of a local atrophic condition of the area covered.

Dr. Gysi has called attention not only to principles but also to materials. His observations regarding the latter have gone practically unheeded. He has shown that the best rubber procurable for our use undergoes a shrinkage of ten per cent when vulcanized under the most favorable conditions. Platinum, gold and aluminum may all be swaged to an adaptation approaching more nearly 100 per cent. I make a plea for the platinum-base porcelain-gum denture, the *ne plus ultra* of prosthetic art. It offers opportunity for the full exercise of artistic genius, embodies a genuine appreciation of the esthetic, and gives its wearer the consciousness which accompanies possession of the best. Platinum does not tarnish and in this respect is superior to any gold which may be used for bases. Porcelain is mineral and therefore more enduring than material of vegetable origin. The porcelain gum is more cleanly than that of other dentures because its highly glazed surface does not encourage the formation of plaques, and the continuous-gum denture, when properly treated, may be rendered impervious to the fluids of the mouth, thus resulting in a structure that is highly sanitary.

The gold-base denture is second only to the platinum-base porcelain

denture. When esthetic requirements of a case do not make the porcelain gum imperative, gold-base dentures satisfy every demand except that of the individual whose sense of well-being prompts him to insist upon the best that prosthetic art can supply. In addition to the thermal stimuli afforded by a gold-base denture, it is characterized by the ease with which it may be kept clean. It does not tarnish quickly and, because of greater density, it may be much thinner than one of aluminum. The prosthetist often finds that a prospective wearer of gold-base dentures views their weight as an objectionable feature. Attention should then be called to the fact that the maxilla has no sense of weight such as the hand or arm possesses. However, it is possible to construct a base of gold for the mandible in which its weight would be objectionable.

With the exception of bases made of platinum or gold, the best base upon which the prosthetist may mount artificial teeth is aluminum. Aluminum is a good conductor of heat and of cold, and accordingly permits the tissues of the mouth to receive the stimuli which vary with the temperature at which different viands are partaken, and which in many instances gives to choice dishes their characteristic and more palatable flavor. One has but to note the normal pink physiological condition of the mouth wearing an aluminum base in order to be convinced that the superiority of aluminum as a material for denture bases is not imaginary.

Dr. W. J. Pryor of Cleveland, Ohio, in a paper read before the American Dental Association, in September, 1923, reported the results of tests conducted by himself and others which tend to confirm the fact that all of the metals employed for denture bases are superior to vulcanite. He also submitted the proposition that the increase in temperature under a vulcanite denture is not so much due to the fact that vulcanite is a poor conductor of thermal changes as to a hyperemia caused by the irritating products of bacterial growth.

The problem of impression taking for the advanced prosthetist has been fairly well solved. Manufacturers have provided us with a cast material that will stand up under the compression incident to closing the flask and during vulcanization. The next *wicket* we have to make, after constructing our occlusal models, is to secure central occlusion. Occlusion is the basis of all dental practice. Central

occlusion should be the basis of all full-denture prosthesis. If we may paraphrase Dr. Mayo's statement of a few years ago: "The next great step in full-denture construction is to secure central occlusion."

Central occlusion is a rest-contact relation of the mandible and maxilla from which all movements of the mandible may be conveniently considered as taking their start. This relation is the one in which the condyles are in their habitually most retruded position. By "rest" is meant "not moving;" when the mandible is at rest (meaning that the muscles are relaxed) it is not in occlusal contact with the maxilla. The occlusal contact is made, of course, through the wax occlusion models or through the teeth, artificial or natural. In your attempt to secure central occlusion do you have the patient put the tongue on the posterior border of the dentures before closing? Do you feel for a contraction of the muscles in the temporal region? Do you force the mandible back to position? Do you have your patient relax? Do you know when you have this correct relation of the mandible to maxilla? Will you not quit guessing and use a technique that is certain? To miss central occlusion to the extent of one millimeter is disastrous to efficient function. This is especially true where the operator has attempted to preserve the cusps of the artificial teeth. If he is satisfied with flat porcelain surfaces, an accurate method of registering central occlusion will make no appeal.

The only method with which I am familiar that gives a correct reading of the proper or improper mandibular relation is the one designed by Dr. Gysi years ago—or some modification of his method. On account of the fundamental character of the object to be attained, this method is of greater importance to the general practitioner than any other single step. The instruments were also designed by Dr. Gysi and consist of a horseshoe plate and an incisal path marker. Following this method, the mandibular-occlusion model is provided with the horseshoe plate, and the anterior portion of this plate is blackened by burning beneath it a pledget of cotton saturated with oil of cloves or some other of the essential oils. The maxillary-occlusion model is provided with an incisal-path marker placed in the median line. When the models are in position in the patient's mouth, being placed so that they are in contact along their entire occlusal surface and glide freely upon each other, the catch that holds

the marker is released, allowing it to touch the blackened surface of the horseshoe plate. The patient is encouraged to move his mandible in every possible direction—anteriorly, posteriorly, and laterally—while contact between the two rims is maintained. Among various other lines, the marker will describe arcs of two circles, which will meet in the form of a Gothic arch. The point of intersection, or the zenith of the arch will find the mandible in its most retruded working position, which is the position of central occlusion.

Dr. F. M. Hight of Houston, Texas, has designed an extension for both the incisal-path marker and the horseshoe plate. This, of course, gives an enlarged tracing and, as it extends six or seven centimeters anterior to the occlusal rims, enables the operator to watch the patient's progress without lip interference, and to maintain this position while the occlusion models are sealed together. It occasionally happens, especially where the patient has been edentulous for some time, or where the bases have shifted to false relation, that the tracing will not assume the characteristic Gothic arch; but, as the pin approaches the apex, it crosses over in a curve to the opposite side of the path. This shows a forward thrust of the mandible.

I believe that the most important phase in the comminution of the food is the final masticatory stroke, and that it is most effective and accomplished most readily when the dentures are returning to central occlusion. Therefore, when I find that a patient does not cut a definite apex in the black field, following the suggestion of Dr. Hight, the mandibular rim is removed from the patient's mouth; and, with the aid of a straight edge, the lines scribing the right and left lateral limitations of mandibular movement are extended to intersect. The occlusal rim is returned to the mouth and, with the incisal-path marker on the zenith of the curve directly posterior to this arbitrary apex, the occlusion models are stapled together. The pin in the marker is engaged in its keeper and the occlusion models removed from the patient's mouth. This relation is transferred to the maxillary cast, which was previously luted to the articulator with the aid of the face-bow. The distance between the arbitrary apex and the point of the incisal-path marker is measured in millimeters, or a piece of base-plate wax is thickened or thinned to equal this distance. This wax and a similar piece is placed in the condyle

slots of the articulator in such a manner as to produce a protrusion equal to the measurement. The mandibular cast is now attached to the occlusal rim, and this in turn luted to the lower bow of the articulator. When the plaster is set the staples are removed, the pieces of wax are removed from the condyle slots, and the incisal-path marker takes its position in the apex of the Gothic arch. After the other adjustments of the articulator have been made the teeth are occluded, finished, and ground to this jaw relationship.

The patient may complain of an uncomfortable feeling for a week or ten days; then the trouble is over. A normal central occlusion is established, and efficient dentures are the result. Compare this with the thousands of dentures made to-day in protrusive occlusion. These cannot approach efficiency, if this correct relation of central occlusion is missed to the extent of one millimeter. Of course, I am speaking of dentures in which the occlusal surfaces still present some semblance of cusps.

You will recall instances where the lingual border of a mandibular denture continually irritated the mucosa, especially in the region of the cuspid. Why? The teeth were milled with carborundum powder in a slightly protrusive occlusion and when the mandible assumes its normal, habitual, central-occlusion relationship, the planes of the cusps drive the denture forward. It is possible to extend the upper bow of Gysi Simplex, Acme, or Kerr articulators to compensate for this condition, if found to occur.

After the casts are properly mounted, the incisal-path marker is released and, by moving the upper bow of the articulator from central occlusion to left or right lateral occlusion, the positions of the rotation centers are found by trial. If the point of the marker shows a tendency to cross the black margin that bounds the area cut in the field by the patient's excursions while in the mouth, the rotation point is carried outward so as to make the Gothic arch acute. The position which the remaining rotation center is to have is determined in like manner.

The above directions are reversed, if the incisal path marker lies within the black margins. The novice should exercise sufficient care in these trial excursions to prevent the pin from cutting the black wax and thereby giving a false marking. This is done by holding the articulator slightly open while moving it laterally.

It will be noted, almost from the time you start to locate the rotation points by this method, that the tracings are not truly symmetrical. Neither are faces. Dr. Cummer of Toronto, Canada, found so many rotation centers outside the condyles that he constructed a wider model of the Gysi adaptable articulator. It sometimes occurs that this marking (Biblio) will show one rotation near the sagittal plane and the other in the condyle head. These facts make the method advocated by Dr. Wadsworth for finding the rotation centers very unsatisfactory (Biblio). While this is true in many instances (in fact the greater percentage of cases have the rotation centers sagitally to the heads of the condyles), it is also true that these patients may be supplied with satisfactory dentures on the Gysi Simplex articulator.

Bennet, of London, proved first that there is a bodily lateral shift of the mandible. Needles has shown that a rotation center may be determined by means of check bites or by the tracing of two points in a manner similar to Gysi's single tracing. Rotation centers should not be considered as definite anatomical structures but rather a mechanical means for reproducing correct movements. Walker pointed out the cause of Bonwill's unsuccessful attempts at balanced occlusion with an articulator permitting a "horizontally forward movement of the condyles," calling attention to the "incline of the roof of the glenoid fossa" (eminentia articularis) and measured the degree of inclination with his clinometer. Christensen was the first to devise a practical method of registering accurately the inclination of the condyle paths. His method (or variations of his method) is in use to-day by Mr. Hanau and others, and is more acceptable than the one taught by Gysi, which requires a registering device for tracing the condyle path upon a card-board. Christensen's method follows.

A roll of warm wax is placed on the mandibular occlusal model and the patient requested to protrude the jaw and close. The condyle heads move forward and downward, registering a definite relation to the occlusal plane depending upon the form of the eminentia articularis. It is necessary not to introduce errors due to the unequal hardness of the wax. The equivalent of this movement may be automatically determined on all articulators having an adjustable condyle incline as follows: The roll of wax, now flattened, is removed and chilled; the occlusion models are returned to the articulator and

sealed to the casts. The set screws holding the condylar slots are released; the flattened roll of wax is placed between the occlusion models and pressure exerted upon the posterior portion of the upper bow of the articulator. The adjusting screws of the condylar slots are moved forward or backwards until the maxillary occlusal model is seated in the flattened roll of wax. This correct position will be determined by the inability of the operator to move with ease the condyle slots. The adjusting screws are tightened and the wax removed, when the occlusal model will return to central occlusion. Dr. Tench calls attention to the greater accuracy to be secured by the use of a right and left lateral check, making use of the incisal path marker to insure against incorporation of a protrusive movement. At this point, the occlusion models are returned to the mouth for setting up the six anterior teeth. I maintain that the best esthetic results may be obtained in the mouth. No subsequent changes are likely to be needed since size, shape, and hue are determined at this time by the patient and others who are likely to be interested.

A chapter might be written and added with credit to our literature relative to rejection of most of the molds and hues from which we select our teeth. We need a better gradation of basic color, a finer attenuation of hues. I have practically discontinued the use of all molds of teeth except those that are wide enough mesio-distally at the cervix to be converted into the required type. Following the suggestion of Dr. Hight, I cut the incisal third of square and tapering type molds to conform to the tapering and ovoid forms, and allow the porcelain above the pins to fill the interstitial spaces, usually filled by the unsightly so-called gum-pink vulcanite.

With the return of the occlusion models to the articulator, the maxillary bicuspids and molars are now waxed into position. These should be so placed that a line drawn through the long axis of the tooth will pass through the crests of the maxillary and mandibular ridges in a line parallel with the direction of force. The mandibular bicuspids and molars are now set up to occlude; and finally the lower six anteriors. Final results are best obtained if the operator centers his activities upon the area of one tooth at a time, i.e., beginning with the first molar, he notes any minor defects in the teeth due to insufficient fusing or overfusing of the porcelain. With the aid of carbon

paper and small mounted stones, he deepens the sulci of the teeth. He does not grind off the cusps. When an intimate relation is established, the morsal surfaces of these teeth are attached with the smallest possible portion of hot wax, the articulator is closed, and the tooth is sealed firmly to the mandibular-occlusion model. With a hot blast of air from the chip blower the thin film of wax is melted, releasing the tooth from the antagonizing teeth. Upon opening the articulator the tooth will be in good position for further observation. In like manner the tooth on the opposite ridge is placed in position. Lateral movements are now tried to determine whether the lingual cusps touch to form the rectangular masticatory groove. This position of the lingual cusps on the working side is easily the most neglected of all essential cuspal relations. It should be secured at the sacrifice of buccal-cusp contact in the wax, if necessary, because the buccal cusps will have found contact when the dentures are finally milled with the carborundum powder. The position of this tooth as well as the positions of the remaining bicuspids and molars are modified to meet the requirements of the movements of the articulator. While the skilled technician knows just the twist or elevation to give these teeth, the novice is not handicapped badly since by experiment he may arrive at a satisfactory result.

The remaining teeth are set up, finishing with the second molars. These vary in their inclination to the occlusal plane, dependent upon the overbite and condylar inclination. If the dentures are to be of vulcanite, means should be provided to return them to the same position on the articulator that the pattern now occupies. Remove the mandibular cast and model that is to be reproduced, pour a bulk of plaster on the lower bow, smooth the surface on a line with the occlusal plane, and close the articulator. Needles uses the face-bow on the articulator to accomplish the same result. This plaster impression of the morsal surfaces of the teeth will permit the denture to be luted to the upper bow in its correct relation for milling. It will also serve as a check on your laboratory help. If the teeth do not seat properly there is just reason to believe that the technician is using bolt flasks or an enormous pressure to close the flask. In our most modern commercial laboratories, these are fast becoming obsolete.

The dentures are now ready to be tried in the mouth. Test the

occlusion for any major discrepancies by holding them together in the hands. If they rock in your hands, it is obvious they will do the same in the mouth. Correct with carbon paper and small mounted stones. The surfaces of the teeth of the mandibular denture should be dry so that the black carding wax used to check the occlusion will adhere. The intaglio of both dentures is now sprinkled with powdered gum tragacanth, and they are then inserted in the patient's mouth. While the patient's jaws are closed the black wax in the bicuspid region is cut away, so that the operator may know whether the closing movement has been entirely completed and is satisfactory, that is, registers central occlusion.

The dentures are removed separately. The articulator is now provided with the House Rotary Occlusal Grinder. By its use the maxillary denture is triturated on the mandibular denture in a minute rotary movement. The movement is accomplished by the movements of two wheels which are off center one-half millimeter. In mounting the case, care should be taken that the centering screws are in place to avoid being off-center. With the aid of the plaster block or face-bow, the maxillary denture is mounted in its original position. By means of the wax central-occlusion check, the mandibular denture is mounted in its correct relation. A trough is formed around the teeth of the mandibular denture with plasticine or modeling clay. The sides of this improvised trough should be sufficiently high to submerge completely all the cusps and incisal edges of the dentures when filled with a paste made of carborundum (No. 120) and glycerine. The centering screws are released and the pulley belted to a motor. The upper bow is raised slightly by the incisal guide-pin and the motor started. The pin is raised and lowered intermittently until the case is ground sufficiently in central occlusion. Right and left lateral excursions are now made slowly—finally, the protrusive movement. This milling usually requires from ten to fifteen minutes, depending upon the intimacy of the cusps at the start, speed of the motor, the grit of carborundum used, and the demands of the operator.

If you close your mouth in central occlusion exerting quite a bit of pressure you will find in most natural teeth a range of movement of one-half to one millimeter where the occlusion is comfortable. While this is very slight, it provides an avenue of escape for food at the

end of the final masticatory stroke. Heretofore we have ground our occlusions to produce a locked relation of the cusps. I am speaking only of those who believe that cusps on teeth were designed for a purpose. Without some play, a slight movement of the base on the supporting structure may be the cause of resorption of the ridges, although the patient may never complain of any discomfort. If slightly worn teeth are examined carefully, the morsal surfaces will present facets, which instead of being planes prove to be curves. The House Occlusal Grinder was developed in order to produce such morsal surfaces on artificial dentures. The writer is enthusiastic in recommending its use because it affords the patient comfort, does not destroy the cusps of the teeth, and provides an escape for food particles in the final masticatory stroke.

729 Shukert Building.

DISCUSSION

Russell W. Tench, D.D.S. (New York City): It was a pleasure to listen to Dr. Campbell's paper. His first remark, that a new era had begun in dental prosthesis, was certainly to the point, and he might also have said that a new era has begun among dental prosthetists. In 1917, when a meeting was held here in New York, it would not have been possible for one dental prosthetist to get up and disagree with another, as I am going to disagree with Dr. Campbell in some points tonight, without seeming to be personal in doing so. While I disagree with Dr. Campbell on some points, I esteem his friendship, and I want to commend many of the things he has said.

The first thing I would like to emphasize is his statement concerning the use of the path tracer to establish the relation of the maxilla to the mandible. This has been in use for twelve or thirteen years. I have personally used it that long, but a year ago I laid it aside. Because such able men as Dr. Campbell and Dr. House were getting satisfactory results without it, I assumed there must be something radically wrong with me. For a year I resorted to the use of the things Dr. Campbell described, and I want to tell you I never enjoyed prosthesis less than I did that year. I had to make over some of my cases, and I am back with the incisal path marker where I ought to be. And if you men are trying to do without it, I know what you and your patients will get into.

There are many other points Dr. Campbell mentioned that deserve emphasis, but the time is too short to talk of them.

I hold no brief for any material. I know you can take a good impression with plaster or compound. It is not the material that takes the impression, but the brain behind the fingers that makes it. If you do not put brains into it, you cannot get a good impression out of plaster any more than out of compound. I think the trouble with those who have had failures with compound is that they have over-extended the periphery. Plaster from its soft nature must be worked to the proper consistency, or you will get an underextension. It can be had with one as well as the other, if worked properly. With compound it must be known that it is easily possible to have the buccal and labial margins over-extended, so they will bear heavily in those regions and result in a temporary fit, if soreness does not compel the patient to discard the denture. I use it in practically 98 per cent of the cases I construct, and I can do better with it than with plaster; but that is no criticism of plaster. You must have a perfect contact of the impression material with the tissue that the denture is to cover, and if you do not, you will have trouble. You can get an uneven contact with plaster wash as well as with compound.

Many years ago, Dr. George Wilson advanced the theory that dentures were retained by adhesion and cohesion. There is no way I know of that you can scientifically prove that what I say is correct, although I have heard it from the platform that it has been proved in a vacuum; but if adhesion is the main factor in retaining dentures, then the destruction of a small area of the denture would certainly not affect the retention of it. If it is adhesion and not atmospheric pressure, it would only affect it in a small way. If you believe this is so, I dare you to take a No. 3 bur and punch two or three holes through the next denture you make, and see if it affects the retention. Atmospheric pressure, I believe, is what retains the denture in place, and it is much stronger than adhesion or cohesion, which is a molecular force.

Dr. Campbell always likes to joke about the grimaces the operator has his patient make when he takes a compound impression. I know he is not serious about that, because the modern prosthetist does not do those stunts. It is a satisfying thing to have the patient laugh and talk and do those things, and know the impression will stay up, but the novice may not know that it is held up in some cases because it is over-extended. If you are careful in your technique, it is a mighty comforting thing to know the impression stays in. Plaster cannot be modified as compound can afterwards.

I am not certain that rubber shrinks 10 per cent. In Dr. Gysi's experi-

ments, which were not made under pressure in a flask, I believe it showed 3 to 5 per cent. This is a serious thing and accounts for much of the trouble we have had. If vulcanite changes 10 per cent, I think it is a pretty big change.

A platinum piece is of course very satisfactory. The only objection I see to using it is that it is too soft. While some patients do not notice it, others do. A combination of silver and palladium has been spoken of, and found to be very satisfactory. Whether this material will eventually supersede gold or platinum for making continuous-gum dentures, I do not know. I have used a little of it, and I have never seen a mouth look better than under this material. It is very difficult to swage. I use a very thin gauge, and it is lighter than any other material, except perhaps aluminum. It does not tarnish in the mouth.

In the matter of bacterial growth, it is undoubtedly true that rubber permits it. I have been told that the Carrel-Dakin solution, known under the trade name of Kerr's solution, is useful to prevent it. We have used about 30 drops to a glass of water, in which patients immersed the dentures overnight, then rinsed them once or twice during the day, when the irritation very materially subsided.

Edward Kennedy, D.D.S. (*New York City*): I feel that I have known Dr. Campbell for some time through his work, but today is the first time I have had the pleasure of meeting him. This summer an editor of one of the dental magazines gave me one of Dr. Campbell's books to review. I immediately read it and found it most helpful and instructive. I can sympathize with Dr. Campbell because I am writing a work on partial dentures, and all the time new things are coming into the field necessitating constant revision of the text.

I would like Dr. Campbell to tell us something about the way to overcome the porosity of continuous gum denture and, if possible, whether he has any suggestions to make for overcoming the porosity of a rubber denture.

I disagree with him about aluminum. Aluminum cast-dentures are porous and in my hands have acted the same as rubber dentures, the porosity causing a sore mouth. If we swage them, they require as much work to make as a gold denture; and it costs only a little more for the gold, which is certainly far more desirable.

Dr. Pryor, of Cleveland, has done some research on bacterial growths on rubber and his results are very interesting. Some years ago, Dr. James Truman performed an experiment to show that it was the porosity of the rubber that caused "rubber sore mouth." He vulcanized a rubber plate

with one-half covered by tinfoil and the other half uncovered. He obtained a sore mouth on the side on which the rubber had been vulcanized against the plaster, but on the side to which the tinfoil had been applied, the hard non-porous surface prevented soreness.

Much has been said about obtaining centric occlusion and I think Dr. Gysi's Gothic Arch Marker is a great help. I do not see why it has not been used more. Dr. Tench is about the only one in the East who has been using it. Drs. Needles and House have gone a step farther and developed a method which shows three of these arches: one in the incisal region, and the other two in the molar regions on either side of the mouth. I think that a similar method will be discovered to solve this very difficult problem.

I would like to say a few words in regard to the fixed and the adjustable condyle-path articulators. It was well understood by Drs. Grittman, Gysi, and Snow that the fixed-path articulator was not a scientific instrument. But as most dentists did not recognize the need of an anatomical articulator—in fact it was not until the time of Dr. Bonwill that they even recognized that the mandible had more than one movement—these men believed that, to educate the dental profession, it was necessary to start with a simple instrument which would give very good results in about 85 per cent of the cases. If Dr. Clapp is in the audience I know he will bear me out in the statement that this is what Dr. Gysi felt when, receding from the position he took with his first instruments, he produced the Simplex Articulator.

In reading over the paper, I did not notice that Dr. Campbell used the word "face-bow," but he has mentioned it here. I believe that every full denture, and most of the partial dentures, should be constructed from models mounted on an articulator by means of the face-bow. [Drawings were made in demonstration.] For years I have maintained that a dentist making plates on a plain-line articulator, which have the casts mounted with a face-bow, would make better plates than the one who used an anatomical articulator without the face-bow. With the more complicated articulators you can adjust the condyle path to fit your bite plate, but you cannot open or close your bite if you do not use the face-bow. Along with the Gysi Gothic mechanism, I believe the face-bow and the anatomical articulator are the instruments which spell success in denture construction.

Dr. Campbell (*in conclusion*): I heartily agree with all that Dr. Tench has said. When you read the paper you will find there is nothing in it that conflicts with his statements, except the point as to which is the primary

and which is the secondary factor in the retention of the denture. I still maintain that adhesion is the primary and atmospheric pressure the secondary physical factor to be considered.

He asked: "what would happen if you would drill a hole in the palate of a maxillary denture?" In many instances it would still be retained. This I used to see demonstrated more frequently when I practised in the Ozark Mountains of Missouri. A patient would come into my office occasionally wearing a denture in two or three pieces. Perhaps you have seen that here. We are convinced that it certainly is not atmospheric pressure that retains these broken dentures. On the other hand, it is a good example of adhesion.

As to the use of a cleaning and antiseptic solution: I find sodium perborate to be very satisfactory. It is as cheap as salt. If the denture is allowed to remain in a glass of water containing a teaspoonful of this preparation, it may be easily cleaned with a bristle brush.

As you know, porcelain in a continuous-gum denture is porous. This is particularly true with regard to the porcelain next to the platinum base. If the denture is boiled in stearin, these microscopic holes are filled. One day, I noticed the workmen for our local telephone company filling with stearin the lead conduits that contain the silk insulated wires. It boiled and bubbled, and stopped only after all the moisture was out. Boil a continuous-gum denture until the bubbling stops and it will be impervious to moisture.

Dr. Kennedy evidently has not read the chapter on the construction of aluminum dentures. A few years ago, his contention about holes coming in aluminum bases would have been valid. We then had to use aluminum which was not pure. Today it may be obtained 99.8 per cent pure. Formerly it contained iron and silicon. Our aluminum bases are all cast, and afterwards swedged on the original Healy or Austin stone model (in this instance the word model is used correctly). We never swedge a denture from an aluminum plate because we feel that we cannot make sufficient grids or attachments to hold the vulcanite securely. In packing, a thin strip of weighted rubber is placed next to the aluminum as it seems to hold better. The packing is then finished as usual. The microscopic particles of iron the old aluminum contained was the trouble maker. Aluminum is a highly electro-positive metal. Free iron in the aluminum base in an acid mouth is a combination of metals that is equivalent to a galvanic battery. The very moment the two metals are placed together in the proper media, in this instance an acid mouth, a disintegration starts that is usually accompanied by a metallic taste. In a month or so holes begin to appear in

the base. There has never been any trouble of this kind since we began the use of pure aluminum. We use it in preference to vulcanite because it can be swedged to a better adaptation than obtains in the case of vulcanite.

I am intensely gratified with your attention and your kindly reception of my efforts. Some day, it may be my good fortune to give you a clinic on cast-swedged metal bases.

THE INTERPRETATION OF DENTAL LESIONS IN THE LIGHT OF RECENT RESEARCH[1]

PERCY R. HOWE, D.D.S.

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The dental diseases to which reference is made are dental caries, pyorrhea, and irregularity of the teeth. Strictly speaking, irregularity of the teeth is not a disease. It is, however, the result of "a departure from normal physiological action," early in life.

DENTAL CARIES

In attempting to assess the value of scientific work, carried out many years ago, and to compare this with recent investigation, it is at once evident that recent investigation has distinct advantages arising from the development of modern scientific methods. It is to the credit of the men of Miller's time that they were able to do so much with the limited facilities then at hand, and that their theories should have stood until to-day. The recent isolation, by means of modern bacteriological methods, of microörganisms associated with dental caries, such as B. acidophilus by James McIntosh, Warwick James, and Lazarus-Barlow; lactic acid bacilli by Captain Rodriguez, and Streptococcus mutans by Clarke, tends to support the work of Miller that was carried out under the disadvantages of his time. In 1917, our laboratory published an account of microörganisms isolated from dental caries, among which were bacteria similar to those described by the above authorities. We later brought out other microörganisms, using enrichment media and various modes of cultivation. We have not, however, succeeded in producing caries in living animals with any of these microörganisms. McIntosh, James, and Lazarus-Barlow also report the futility of their efforts to produce caries in rabbits or monkeys with B. acidophilus, with the possible exception

[1] Read at a meeting of the New York Academy of Dentistry, New York City, at the Hotel Belmont, March 26, 1925.

of slight caries in one monkey. In a further attempt to produce caries, according to Miller's theory, guinea pigs were fed various sugars and starches in excessive amounts without result. More recently we fed monkeys a diet containing considerable white flour and sugar, and in addition, twice daily, a sticky candy made by boiling cane sugar and water. No caries followed except in one animal. This animal had a history comparable with that of other animals that developed caries on a different type of diet, and we therefore attributed the caries to a digestive disturbance rather than to the local action of the sugars and starches. Two of these animals died from other causes at the end of eight months, when their teeth were found to be covered with a mass of adhesive carbohydrates, which was removed with difficulty, but no caries was found. No further support of Miller's theory is to be found in modern researches. The production of caries in living animals by bacterial means has not yet been accomplished. It appears then, from recent investigation, that the bacterial flora of caries is to be regarded as of secondary importance and that Miller's theory is not an adequate explanation of the full phenomena of dental caries.

On the other hand, dental lesions have occurred in the course of deficiency feeding experiments that are too significant to be overlooked. These changes include the formation of thin or defective dentine, hypoplastic enamel, chemical alterations in teeth already formed, and the occurrence of caries in the teeth of monkeys. The dental defects reported by Mrs. Mellanby, Zilva and Wells, Grieves for McCollom, Marshall for Lucas and Jones, have resulted from various types of improper feeding. In all cases the dental lesions have been the result of physiological disturbance induced by the character of the diet. Mrs. Mellanby has especially studied the fat- soluble A, or a vitamine closely related to it. She does not regard the amount of calcium in the diet of great importance, providing a sufficient amount of this factor is present. Grieves on the contrary found the least damage to dental tissues when the calcium was high and the fat-soluble A, low in the diet. Marshall found dental changes in the teeth of young dogs, very similar to those described by Mrs. Mellanby, when fed on diets employed by Lucas and Jones, which were said to have no vitamine deficiency. Zilva and Wells reported dental changes in guinea pigs on a scorbutic diet. Häger, in a recent mono-

graph, describes histological changes in the teeth of scorbutic guinea pigs. Toverud analyzed the teeth of scorbutic animals in my laboratory, and found a loss of ash, phosphorus and calcium, with an increase in magnesium. In fourteen animals he found an average of 2.9 per cent of magnesium while the teeth of controls contained only 1.1 per cent. In an analysis of fifty human teeth, twenty-five of which were sound and twenty-five carious, he found an average of 0.7 per cent magnesium in the sound teeth as contrasted with 1.2 per cent in the carious teeth. Further work of his own, on pregnant rats fed on a low calcium diet, showed an alteration in the molar teeth. He found a low ash, low phosphorus and calcium with an increase in magnesium. The blood of these animals contained but 6.5 mg. of calcium per 100 cc. as against 11 to 12 mg. for normal rats.

Caries was developed among our monkeys under a variety of dietary conditions, which fact, taken in connection with the results of other investigators, leads us to believe that this dental lesion is a sequence of faulty mineral metabolism. Some of the more prominent dietary characteristics that are of importance in the recurrence of caries are the amount of calcium in the diet, the relation between acidic and basic ash, the amount of antiscorbutic substance (and to some extent certain properties found in various fats, as in cod-liver oil), the indigestible residue in the diet, and the amount and character of the proteins. In other papers, I have described the action of these various factors in monkeys.

Thus recent research shows the need of a modification of some of our ideas on caries which have long been held. Black's theory, that teeth are all alike chemically and physically, is confuted. It is evident that teeth not only differ in their composition but that they may change after being once fully formed. By many, this has been thought impossible. Inasmuch as dental lesions have resulted from various dietary causes, and not from local agents, we can only conclude that caries is due fundamentally to a derangement of metabolism which includes numerous factors. It is through metabolism that the characters of the oral fluids, the type of bacterial flora, and the structure of the teeth, are determined. In experimental animals the teeth are one of the first parts to show changes induced by the character of the diet. This fact apparently confirms the statement of Sir

Arthur Keith who remarks that the teeth are the first part of the body to disintegrate.

PYORRHEA

I do not know of any agreement as to the cause of pyorrhea. From time to time various microörganisms have been described that have been thought to be the causative agent. By some, pyorrhea has been said to be due to a mixed infection. It has not been produced experimentally by bacterial means. The amoebic theory was of short duration. To-day, I believe it is generally conceded that the microbic life in pyorrhea is a secondary factor.

Box made a thorough pathological examination of the tissues involved in pyorrhea. He considers two types of the disease. One, which occurs in the fewest instances, he described as an ulceration beginning at the gum margin, progressing into the peridentium, and denuding the cement. By a still further progression of this process the surrounding bone becomes involved. The other type he calls a fibroid degeneration of the peridentium, not beginning at the gum margin as an ulceration. This process extends into and replaces the bone with pus formation. He believes this condition is due to over-functioning of the parts brought about by excessive mechanical stress on the teeth. Box also demonstrated re-attachment of the peridental tissues to denuded teeth. This is an interesting and practical fact. In such cases the fibers of the new tissues are arranged parallel with the tooth instead of transversely. From a pathological standpoint Box's work is quite convincing. But there are other interpretations of the cause of over-function. This is seen to occur in many parts of the body where there is no abnormal stress. It has been estimated that, after the age of forty, about 85 per cent of people have a tendency to pyorrhea. About 85 per cent of house dogs also have pyorrhea. In many of these cases the occlusion is, or was, within the normal range. If stress is such an important factor, it seems strange that teeth should endure undue strain for twenty-five years, only to show its effect at the end of that time. On the basis of traumatic occlusion, how shall we account for pyorrhea that occurs about teeth which, for years, have had no opposing teeth to strike upon?

Among our monkeys we have observed every stage of what appears

to be pyorrhea. This may be seen as a marginal gingival redness, or as a swollen and congested condition of the gums. The soft tissues in some cases have sloughed off, leaving the alveolar process exposed. The lips themselves have been eaten into. Accompanying this condition is progressive destruction of the alveolus or maxillary bones. During this state of disease, teeth that formerly occluded normally, drift, and abnormal articulation occurs. Mrs. Mellanby and McCollom have produced marked changes in the supporting tissues of the teeth in their animals. Recent research therefore confirms only the metabolic theory of pyorrhea, for in all cases where pyorrhea has resulted, it has been brought about by abnormal feeding.

IRREGULARITY OF THE TEETH

Numerous theories have been offered to explain irregularity of the teeth, such as mouth breathing, thumb sucking, premature extraction and heredity. The latter two undoubtedly play a part. Possibly mouth breathing and thumb sucking are also factors in this condition. The most common cause, judging from experimental results, has to do with growth and calcification of the maxillary bones, and muscular development. Should bone growth and calcification lag behind muscular growth, the too plastic bone is narrowed and distorted by the strain of muscular stress. The narrow high arch follows and, owing to lack of space, the teeth erupt irregularly. The nasal passage is also often changed. These results are again due to improper feeding. One common example of this, is to be seen in the difference between infants fed at the breast and bottle-fed babies.

On the whole the present theories of dental diseases, in the light of recent research, receive but meagre confirmation. Instead of having to do with simple local agencies, prevention means the correction of faulty diets, and for the solution of our problems we must look into physiological fields rather than limit our efforts to mechanical procedures.

DISCUSSION

Milo Hellman, D.D.S. (*New York City*): It is a big order to open the discussion of a paper of this kind. Although the paper itself is rather short, the slides that were shown by Dr. Howe, speak volumes.[2] I should

[2] The illustrations have not been presented for publication.

like to know whether those decayed first permanent molars (I do not believe they should be called sixth year molars, because in the monkey they erupt much earlier) had erupted when the feeding with the faulty diet was instituted.

Dr. Howe: They were mostly erupted. We have not kept our animals over two years, so what decay there was, developed rapidly. We examine all the animals that come into the laboratory, so that we are certain there is no decay to start with. I have found only one monkey with dental decay in all the examinations made at our laboratory.

Dr. Hellman: Were the incisors that had perforations, or little holes, completely covered with enamel before the diet, or were they worn down? The monkey's incisors are worn down quickly and very early, so that the dentine is exposed. I should also like to know, if the permanent molars were erupted and yielded to decay, why the deciduous molars did not decay?

Dr. Howe: I do not know.

Dr. Hellman: Would it not be plausible that those first molars were defective in structure to begin with? That the grooves were fissured and insufficiently united?

Dr. Howe: That might be so. There is a great difference in these molars after the monkeys have been placed on the diet. In an animal that has been fed normally, the molars become exceedingly hard, but when they have been on a deficiency diet the molars have a tendency to become soft. I do not think enamel is as much a protective agent against caries as many think. I think it is a mechanical protection against wear. This is exemplified by the fact that in monkeys and apes many teeth are found with defects in their enamel, and yet there is no decay. Take my own case. I was hit with a baseball many years ago, and much of the enamel was removed, but there has been no decay. Still, teeth that are covered with glass-like enamel are better fitted to withstand wear than teeth that are not. I think where there is decay, there is some defect in the structure of the teeth.

Mothers do not breast-feed their youngsters much over three months nowadays. The child is given artificial food as soon as possible. We know that cow's milk is made for the calf and not for the human being. Cow's milk clots into a dense thick clot, while human milk clots into fine curds which are easy for the child to assimilate. Human milk contains more of the globulin and albumin than cow's milk, and not so much of the casein. It does not contain as much lime, but more lactose. All this is definitely related to the development of tooth structure.

Dr. Hellman: These points bring up an interesting phase of the situation. I made the statement some time ago that the deciduous teeth are not as much subject to caries as the permanent teeth. The reason is this; that the deciduous teeth develop at a very early period in the life of the indi-

vidual, and consequently under more favorable conditions. The first permanent molars develop during a period of stress in the life of the individual, i.e., the time when the transition from a dependent life to an independent life takes place. As a result, we find the first permanent molars more defective than any of the other teeth. This may be due to the transition into an unfavorable environment. Monkeys are known to suffer from rickets and osteomalacia even in their wild states. It is therefore necessary to be cautious in compiling data in regard to experimentally produced bone defects.

The hands shown by Dr. Howe interested me very much. While they bear interesting witness as to the ossification of the epiphyseal cartilages, it really has little significance because we do not know the extent of variability under normal conditions. Two individuals may be equally normal, and yet one may have the epiphysis united and the other the epiphysis un-united. This depends on the range of variability of this process.

I wish to thank Dr. Howe for his interesting talk and the beautiful slides he has shown. They gave me a tremendous range of vision of the many ways in which these disturbances might be demonstrated.

W. D. Tracy, D.D.S. (New York City): I do not think I can add very much to the discussion. I believe, however, all thoughtful dentists realize that we must look more and more to the dietary factor as to the cause of caries. It is a matter of extreme interest. Dr. Howe expressed his own opinion that perhaps we, as a people, are consuming too much cereals. For a long time we have been told that there is nothing better for us than the whole grains. I have been impressed with the idea that people are in better health who take a great deal of whole wheat than people who use cream of wheat and the ultra refined breakfast foods. Does Dr. Howe regard whole wheat in the same light as he does the refined and prepared cereals? I believe if a patient can take whole wheat, with the husk on, more mineral element is obtained and also sufficient roughage, which is helpful for proper peristalsis.

Dr. Howe (in conclusion): Dr. Tracy speaks of whole wheat. He says it is beneficial for the stimulating effect of the roughage, and it is preferable to the refined foods. However, we should be careful to have our food balanced on the alkaline side, rather than on the acid side. Milk just about takes care of itself, and we should have plenty of vegetables. This is only suggestive, as there is nothing definite in this regard.

I agree with Dr. Hellman's theory regarding the temporary teeth. A child depends to a certain extent upon pre-natal feeding. Under ordinary

circumstances the child receives the material it needs and it is the mother who suffers. But as the child advances in age, and artificial feeding is instituted, we observe the advent of defects.

About the hands: this was just an interesting observation. It happens that the boy who had delayed calcification of the bones also had decay of the teeth. It might have been a coincidence, and I would not make predictions on evidence of this kind.

In closing I might tell you of an experiment by Prof. Wolbach and myself on a dozen guinea pigs. We opened into the femur of twelve animals, and then fed six of them with orange juice. The other six animals had no orange juice. Those that did not receive orange juice had no healing in the bone. Those that did receive orange juice had rapid healing in the little trough we made in the bone.

AMALGAM FAILURES

Where is the Fault: In the Alloy or in the Operator?[1]

WILLIAM E. HARPER, D.D.S.

Chicago, Illinois

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INTRODUCTION

Of the test fillings made for me by experienced operators, over 90 per cent leaked as soon as exposed to air pressure from within, and more than half of them were weak and unstable. I come prepared to make amalgam fillings, over 95 per cent of which will be non-leaking, strong, and stable. This statement, if true, answers the question, "Where is the fault?"

Alloys made by reputable manufacturers may be considered high grade when containing 65 per cent of silver. Alloys containing less than 65 per cent of silver generally shrink too much, are commonly weak in their resistance to crushing stress, and flow to a dangerous degree. Alloys containing more than 70 per cent of silver work too harshly, and set too quickly for general use. The slow-setting alloys are so deficient in many essential qualities, and are so wasteful of the operator's time, that I feel they are not worthy of consideration.

[1] Read at a meeting of the First District Dental Society of the State of New York, at the New York Academy of Medicine, December 4, 1925.

When high-grade alloys are used, *all* dangerous shrinkage and expansion, commonly observed in amalgam fillings, may be caused to take place during the mixing and the packing of the filling, at which time the faults will be corrected by the use of a correct amalgam technic, eliminating dangerous movement, and developing maximum strength in the finished filling. Alloys are made quick- and medium-setting. Rapid and skilled operators may safely use the quick-setting alloys for the one purpose of saving the operator's time. Average slow or slow operators must use the medium-setting alloys to be assured of the necessary time for thorough packing. During amalgamation (mixing in the mortar) we always have shrinkage; as setting predominates, we have expansion. If amalgamation (mixing) be made sufficiently complete in the mortar, and the amalgam tightly packed, practically no amalgamation remains to take place in the finished filling to cause secondary shrinkage and expansion.

Amalgamation develops the following reaction: dental alloy, largely Ag_3Sn, combines with the mercury, as indicated by the equation: $Ag_3Sn+4Hg=Ag_3Hg_4+Sn$, and remaining excess mercury. The shrinkage observed in high grade alloys occurs during this physical change, followed by expansion, as setting predominates. Mixing in the mortar develops this reaction; time, and the temperature of the mouth will develop a secondary reaction in the finished filling by diffusion, if unamalgamated particles and much excess mercury remain. Thorough mixing, orderly and tight packing, will reduce this secondary amalgamation to so small an amount as to eliminate all danger of disturbance to adaptation. Rapid rubbing for two to three minutes (a small mix two minutes, a large mix three minutes) in a slightly dulled, deep glass mortar, with a pestle shaped to make contact with the curved bottom and the full depth of the sides of the mortar, are the imperative requirements for a complete hand mix. Shallow mortars and poorly shaped pestles *prohibit* a complete mix, and I emphatically condemn their use. A mortar and a pestle of proper size and shape are of the first importance; a means to measure accurately the time of mixing (two to three minutes) is of second importance; and both are absolute requirements for perfect results. *This simple detail of operative procedure is woefully neglected*, and accounts for many of the dimensional changes that time develops in our amalgam work.

PLASTICITY

Insufficient plasticity has been the rock on which we have wrecked 70 to 80 per cent of our amalgam fillings. Adaptable plasticity of the amalgam during the process of packing against cavity walls and margins is the *most* important detail of operative procedure necessary to adaptation. The profession has failed to make the distinction between a workable and an adaptable plasticity. This distinction *must* be recognized to insure the necessary plasticity. An ordinary mix of a quick setting alloy remains adaptably plastic two to three minutes only; and in the average large occlusal or large proximo-occlusal cavity two to three minutes is insufficient time in which to apply a thorough packing technic. To increase this *too-short* packing time, we mix quick-setting alloys *decidedly* plastic, retaining much of the excess mercury until adaptation is secured, after which it may be readily and completely removed by forcible and orderly packing. We may build fillings to perfect form and strength with a workable plasticity, but we must have adaptable plasticity to make a non-leaking filling.

Crepitus developing during the application of orderly packing indicates *loss* of adaptable plasticity, although the mass may remain easily workable and appear to be smoothly plastic.

TAMPING

Tamping in its effect and purpose is similar to agitation, or jarring a plastic mass. Tamped amalgam settles or flows without break into all surrounding angles, and against all cavity walls as a solid layer, *free* of air voids, retaining its original plasticity as it flows to exact place. All that now remains to be done is to compress it forcibly to remove the excess mercury, and *wedge* the amalgam into *pressure-contact* with the cavity walls, at which moment it will *immediately* harden and stay put. When amalgam is packed to place by force, instead of by tamping, it perceptibly stiffens with each thrust of the plugger. In this manner it loses its adaptable plasticity *before* adaptation is secured, and a leaking filling is commonly the result. By tamping we place and build the amalgam as a layer *free* of all air voids, retaining its original plasticity. As we compress this solid layer of

amalgam it cannot crack or break because the solid layer by which it is surrounded holds the amalgam under the plugger-face to receive the *maximum* compression.

For these reasons we should place and build our amalgam by tamping, resorting to forcible packing for the *sole* purpose of removing the unattached tin and excess mercury, and finally to wedge the amalgam into the tightest possible pressure-contact with the cavity walls.

CONDENSATION

With the amalgam placed and built by tamping, in the new technic, the *one* purpose of condensation is to express the tin and excess mer-

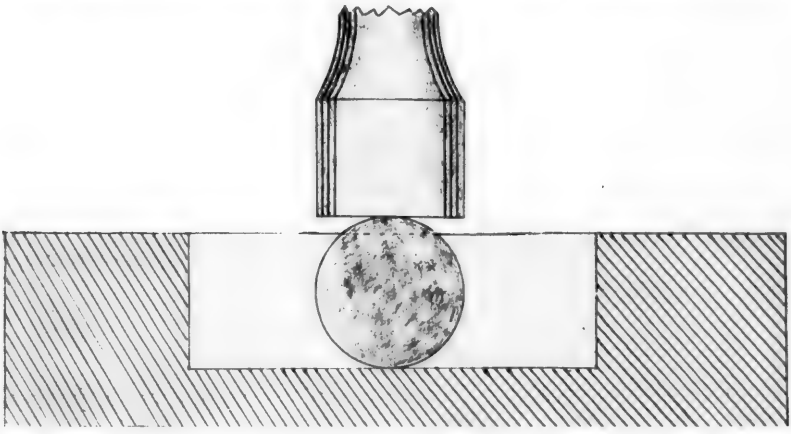

Fig. 1. A ball of amalgam placed in a cavity, as shown in *fig. 1*, when packed with one thrust of a large plugger will break and crack as it spreads into the surrounding space, as illustrated in *fig 2;* and subsequent packing with the same plugger will *fail* to *completely* eliminate these voids.

cury, and to drive and wedge the amalgam into pressure-contact with the cavity walls and margins. Very few amalgam operators pack amalgam with sufficient force to develop pressure-contact to cavity walls, and to remove reasonably well the tin and excess mercury. A weak, leaking and unstable filling is the result. A filling to be uniformly strong and perfect must be packed with an *equally*-applied force of nine to sixteen pounds, which is best accomplished by orderly

stepping the plugger in *one* direction from the center of the filling to the cavity walls.

Packing done without order makes a filling weak and defective in *spots*, and develops many mercury pockets. Packing done by an

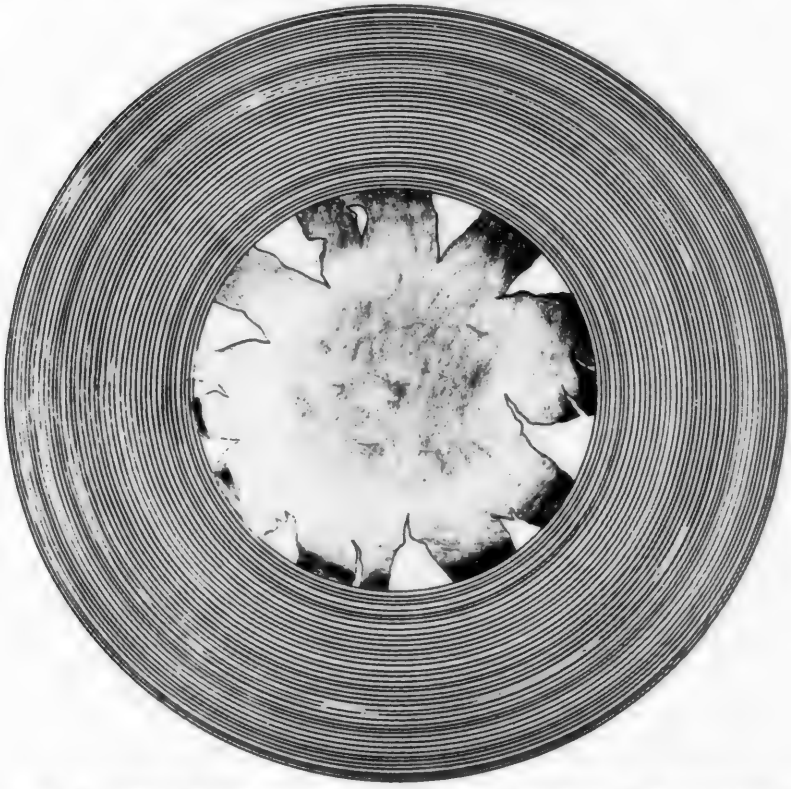

Fig. 2. Illustrates how amalgam cracks as it spreads from under the packing force; and subsequent packing with the same plugger will fail to completely eliminate these voids.

orderly applied force, working from the center of the filling, condenses each part of the filling equally, and the excess mercury is kept moving in *one* direction, *outward*, where it is at all times free to appear on the surface, to be removed as it accumulates.

STEPPING THE CAVITY WALLS

In packing the amalgam we find the round pluggers the most generally applicable. In packing against cavity walls with such pluggers,

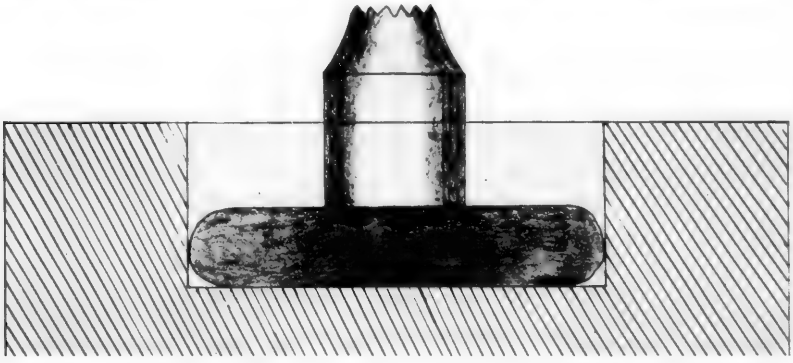

Fig. 3. A side view of amalgam after packing with one forcible thrust of the plugger (note the rounded edge). Where the crest of the rounded edge makes contact with the surrounding walls it prevents further spreading in the directions of line angles, and particularly toward point angles, bridging an angular void. Naked eye defects are *always* located at *point* angles.

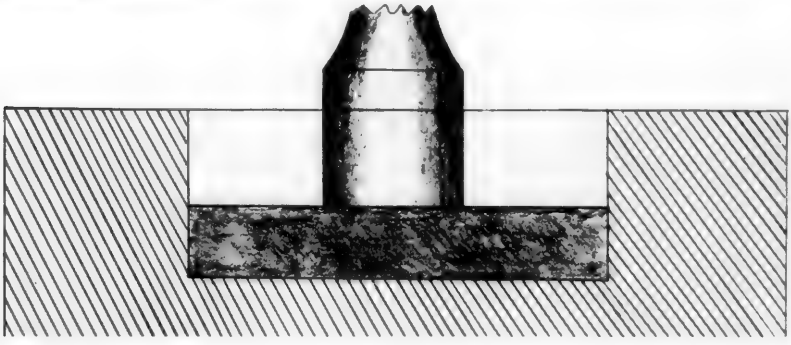

Fig. 4. Amalgam jarred into a cavity will flow as a solid plastic layer into contact with surrounding cavity walls and angles, free of breaks and voids, as illustrated in *fig. 4*. Tamping will accomplish the same purpose. It is easier to avoid cracks and imperfections in placing the amalgam by tamping than it is to eliminate them by forcible packing.

we fail to compress small triangular areas between the steps; at such points excess mercury will be pocketed and imperfections will occur.

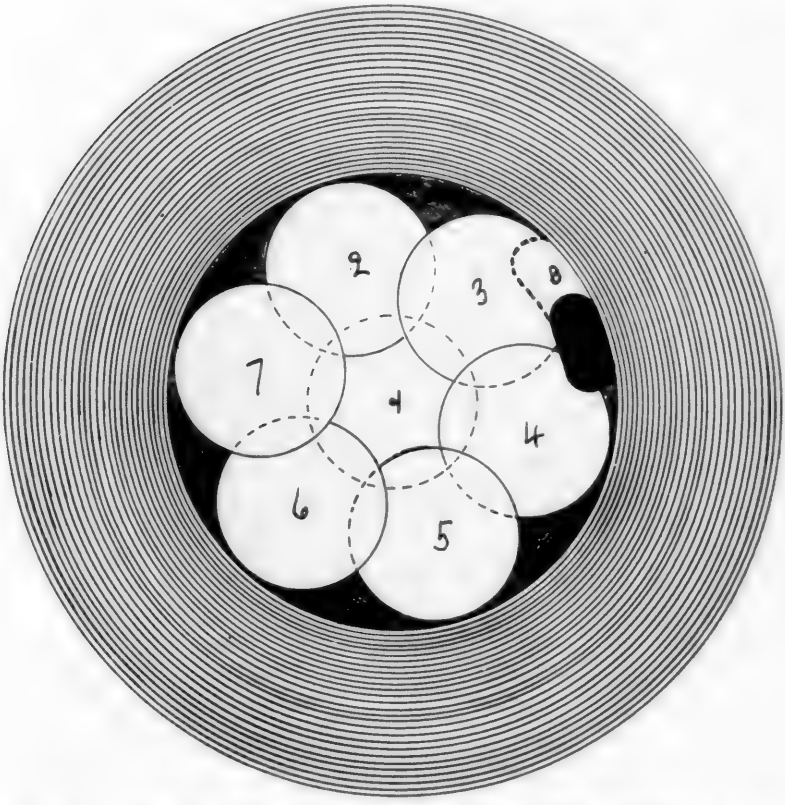

Fig. 5. Intended to illustrate orderly packing. After placing amalgam as a solid plastic layer by tamping, we start to pack the amalgam forcibly at the center of the filling, stepping the plugger as indicated by the numerals 1, 2, 3, 4, 5, 6, 7. This orderly movement of the plugger from within out keeps the excess mercury moving in *one* direction, *outward*, where it is free to come to the surface to be scraped off with the side of the plugger. Orderly packing gives equal condensation throughout the filling. The final condensation is made by stepping in one direction once around the cavity walls with a very small oval plugger.

The reduced size of the plugger greatly increases the packing force applied. The small area makes it possible to penetrate to the depth of pockets commonly located about the cavity walls, to correct minute imperfections and most forcibly to express the final excess of mercury. Irregular packing results in unequal condensation and develops many mercury pockets, which cause failure to express much of the excess mercury.

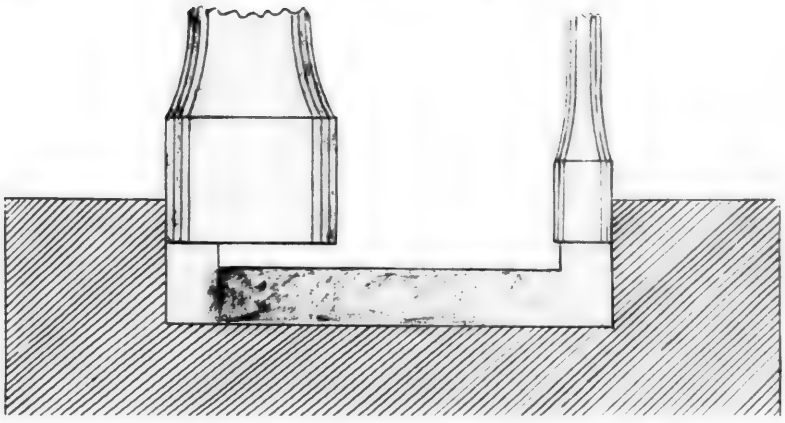

Fig. 6. Intended to illustrate the penetrating power of the small plugger. Small areas or pockets insufficiently condensed require the use of pluggers small enough to penetrate to their full depth. With a large plugger you cannot condense deeper than contact of the face of the plugger with the amalgam previously condensed.

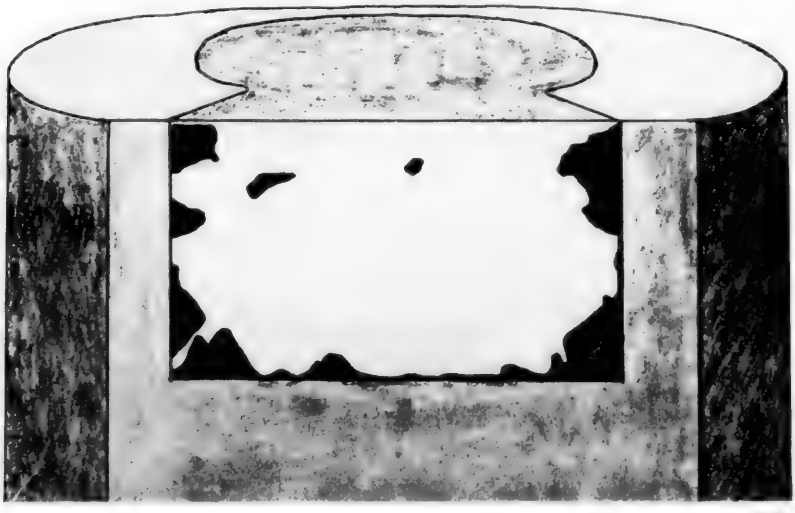

Fig. 7. Of the test fillings made for me as long as ten years ago, over 50 per cent revealed naked-eye voids as shown in this diagram. Since that time the profession has gradually recognized the great need and importance of a *decided plasticity* when filling proximo-occlusal cavities, and the naked eye appearance of the test fillings made for me has greatly improved, seldom showing other than minute naked-eye defects, generally located at the point angles.

Forcibly stepping the cavity walls with a plugger *small* enough to *penetrate* to the depth of these uncondensed areas is absolutely necessary to remove pocketed mercury, to correct minute defects, and again to wedge the amalgam into the tightest possible contact at this vulnerable point. As the filling approaches completion and the cavity walls are covered, the mercury should be pinched out of the remaining mass to the point where it still remains workable. The cavity should then be filled with an excess, covering well all margins, after which we condense thoroughly. This final condensation may be done with the mallet.

If a quick-setting alloy has been used, we may proceed immediately to carve the occlusal surface with a sharp discoid excavator about 3 mm. in diameter, cutting lightly towards the cavity margins. The two to three minutes taken for the carving will permit the amalgam to harden sufficiently to permit the safe removal of the matrix, by drawing it rootwise to the buccal or lingual, if the amalgam has been tightly packed. We now trim away the overlaps on the proximal surface, and burnish the amalgam lightly with a root-canal plugger bent to reach all parts of the proximal surface, followed by lightly burnishing the occlusal surface, which completes the filling at *one* sitting.

After securing the matrix, where one is necessary, I always insert a tapered wooden toothpick, generally from the lingual, to wedge the matrix into close contact with the gingival cavity margin, by which means we help to enlarge the interproximate space, and avoid any overlap at this point.

PACKING PRESSURES

During the past few months I have been gathering, from members of the profession, a record of the pressure exerted in packing amalgam fillings. Up to date, I find about 40 per cent of the operators pack with a force averaging under seven pounds. Nine to sixteen pounds of orderly applied pressure is required to remove dependably the tin and excess mercury, and to secure adaptation. Many failures will result with packing pressures of seven to nine pounds, and uniform failure will result when fillings are packed with less than seven pounds.

A tightly packed amalgam filling requires *no* grooves and undercuts

to retain it; parallel walls and a square seat will retain the largest amalgam restoration when packed with nine to sixteen pounds.

PURPOSE OF TIN IN AMALGAM AND ITS ATTENDANT DANGERS

My experimental and clinical test-work leads me to the conclusion that tin alone is responsible for the flow observed in fillings made from high-grade alloys. The remedy will be found in the use of an orderly packing of sufficient force to express most completely the unattached tin and excess mercury. The more completely the finished filling is made up of the compound Ag_3Hg_4 and possibly a similar compound of copper and mercury, the stronger and more stable the filling will be.

Tin in amalgam serves three purposes: it facilitates amalgamation, lubricates the amalgam so that it moves on itself without drag when packing, and retards the setting sufficiently to provide time for thorough packing. After these purposes have been served, the more completely we remove it, the stronger and more stable the filling will be. *Copper amalgam does not flow*, probably because it contains no tin.

PULP PROTECTION

Many more cases of pulpitis occur under amalgam fillings than with any other permanent filling material because (a) amalgam is depended upon as a last resort; (b) we do not prepare the cavity with the same care as for gold, commonly leaving decay in close contact with the pulp and (c) we do not recognize the necessity of protecting the thin yielding wall of dentin, immediately over the pulp, from packing pressure applied at this point when inserting the filling. This dangerous pressure against the pulp, if developed, remains as a permanent irritant to be gradually increased, and subsequently aggravated into pain by thermal changes that would have been tolerated in the absence of this irritating pressure.

SUMMARY

Proportions of alloy and mercury need not be exact, but mercury should *always* be in perceptible excess during the mixing. A considerable excess during the mixing will do no harm, but a slight insufficiency is dangerous.

The best and only dependable guide to insure a complete mix and adaptable plasticity is *accurate* timing.

Plasticity *free* from crepitus during the procedure of orderly packing is imperative to make a non-leaking filling.

Fillings must be placed and built by tamping (not condensation). Following tamping we condense to remove the unattached tin and excess mercury, and drive and wedge the amalgam into pressure-contact with the cavity walls.

Orderly packing and stepping the cavity walls has proved the best procedure to insure *equal* condensation and the most complete removal of excess mercury, and is the most effectual technic to make air-tight adaptation as the final detail of the packing procedure.

The use of a good alloy does not guarantee a good amalgam. The dentist makes the amalgam, not the manufacturer of the alloy, and the amalgam is only as good as the mixing and packing process applied by the operator. Weak packing force will *always* make a soft, unstable filling, however good the amalgam used. A soft filling loses its margins by wear, developing the black ditch, which many have considered due to spheroiding or to excessive shrinkage.

However good the alloy used, we *must* pack with an orderly applied force of nine to sixteen pounds to make a uniformly perfect filling.

The strength and stability of the finished filling is in proportion to the amount of tin and excess mercury expressed in the packing. The more tin and mercury expressed, the stronger and more stable the filling.

The average sized mesio- or disto-occlusal cavity filled with a medium- or slow-setting alloy will require as much of the operator's time as would be taken when restored with a gold inlay. If this be true, how can we justly charge a reduced fee for our amalgam service?

Average sized proximo-occlusal fillings can be inserted and finished at *one* sitting of fifteen to twenty-five minutes when quick setting alloys are used. The same cavity filled with a medium- or slow-setting alloy would require forty to sixty minutes, necessitating a second appointment to make an equally good finish. To make it possible to collect a just fee for our professional service, under these circumstances, we *must* learn to use the quick setting alloys to reduce justly the cost of our service to the public.

Incomplete mixing and insufficient plasticity will make a leaking filling that may be strong in its resistance to crushing stress and flow if packed with force.

Weak packing makes a soft filling that will develop *every* fault characteristic of bad amalgam work.

A correct amalgam procedure, that will assure a uniformly perfect filling, is dependable upon the application of the following order of procedure: Proper cavity preparation; the use of a perceptible excess of mercury in the mixing; thorough mixing for two to three minutes; a plasticity *free* from crepitus during orderly packing, for all except small and shallow cavities; thorough, orderly, and forcible packing; stepping the cavity walls; proper proximal and occlusal form and finish; a firmly-held matrix wedged at the gingiva, when the use of one is necessary; protection of the pulp from packing pressure in all deep cavities.

You may jar amalgam into an impression, using the pressure of the finger as you jar it for five to ten seconds, and make a 100 per cent perfect model without failure; but you cannot secure air-tight adaptation by this procedure, because it will not develop pressure-contact of the amalgam to cavity walls. We must drive and wedge amalgam against cavity walls to secure pressure contact.

It has been the germicidal power of most good amalgams that has saved the teeth, *not* our operative skill and care.

Amalgam is the most generally used and the most abused of filling materials, representing more than 50 per cent of the income of the average dentist. Why not honor our profession by its more intelligent use?

DISCUSSION

John T. Hanks, D.D.S., F.A.C.D. (New York City): "The manufacturer makes the alloy, the dentist makes the amalgam." This statement, made by the essayist, struck me with the force of a slogan, and emphasizes a fact which should be thoroughly understood by every operator using this particular filling material. There is an interdependence between manufacturer and dentist which is not clearly defined. The merits of different alloys are heralded, claims of results of laboratory tests showing valuable properties are glibly discussed, until the dentist is convinced that the mere use of this or that alloy is all that is necessary to accomplish wonders, losing

sight of the fact that the success or failure depends almost entirely on his own efforts. The most emphatic stress must be laid on the fact that good amalgam fillings are the result of careful painstaking manipulation on the part of the dentist. The best alloy ever made can be so mishandled that a filling having the appearance and consistence of Swiss cheese will result. I would like to submit two charts indicating in concise form the factors within the control of both manufacturer and dentist, and also the responsibility of both manufacturer and dentist.

A. FACTORS WITHIN THE CONTROL OF THE MANUFACTURER

1. Choice of ingredients
2. Proportions of ingredients
3. Methods of preparation
   (a) Melting
   (b) Cutting
   (c) Annealing

a. Responsibility of the manufacturer

1. Furnish alloys of a desirable character
2. Inform the dentist of the true form and nature of the alloys furnished
3. Inform the dentist of the most advantageous way of manipulating the alloys

B. FACTORS WITHIN THE CONTROL OF THE DENTIST

1. Correct operative technique
   (a) Cavity preparation
   (b) Matrix application
2. Ratio of mercury to alloy
3. Time and method of mixing
4. Technique of insertion of the amalgam
   (a) Adaptation and condensation
   (b) Removal of excess mercury
   (c) Carving
   (d) Polishing

b. Reponsibility of the dentist

1. Prepare all cavities according to accepted scientific procedure
2. Apply a matrix in all three wall cavities
3. Use sufficient mercury to produce a smooth plastic mix
4. Mix vigorously in the mortar for at least three minutes
5. Insert in plastic form to secure adaptation to the walls of the cavity. Condense by tamping and stepping. Remove excess mercury. Carve to anatomical form
6. Polish at a future sitting

I wish to thank the essayist for his untiring efforts in spreading the light of better amalgam technique.

R. Ottolengui, M.D.S., D.D.S., LL.D., F.A.C.D. (New York City): I really felt very grateful when I received an invitation to discuss this paper, and for the following reason. Last summer, at our State Society meeting, I presented a report on amalgam based on the investigations of the Research Committee for the previous year. This report was published in the *Dental Cosmos* for October 1925, and since its appearance I have received numerous letters which indicate that my position has not been comprehended. I have evidently left an impression upon some minds that I am opposed to amalgam as a filling material. This is not true, and I am glad of this opportunity to again state my views.

In the report above alluded to, I recorded the fact that I had examined 1067 extracted teeth which contained amalgam fillings, and that the failures were as follows: Buccal surfaces, 69 per cent; approximal surfaces, 80 per cent; occlusal surfaces, 17 per cent; percentage of failure for all surfaces, 50 per cent.

These figures have been criticized severely. It has been claimed that the examination of extracted teeth is no fair criterion of the dependability of amalgam, since extracted teeth are naturally teeth that have been discarded; that probably many of these teeth had been extracted for the very reason that caries had supervened about the amalgam fillings, in many cases even producing toothache because of pulp exposure. This contention is perfectly sound, and there is no doubt that, like all statistics, these are somewhat faulty. Nevertheless, certain facts were brought out which were undoubtedly both accurate and significant.

At the moment, however, I wish to compare the statements of that report with the claims of to-night's essayist. It has been said that I am prejudiced against amalgam, and that, when I arraign it as giving inadequate service to the poor, claiming that amalgam is not a cheap filling, I have shown an ignorance of the needs of the poor, and have become an advocate only of high priced operations. Our essayist who undoubtedly comes to us as an advocate of amalgam, believes that good service can be rendered to rich or poor with amalgam, yet what do we find him saying? At the very opening of his paper he says: "Of the test fillings made for me by experienced operators, over 90 per cent leaked as soon as exposed to air pressure from within, and more than half of them are weak and unstable."

Think of that, my friends, and compare these words with my own. In my report I declared that an examination of amalgam fillings from unknown

operators, many of whom must have possessed only mediocre ability, and some, if I might judge by their work, having no real ability at all, showed that in approximal cavities, the most difficult situation of all, 80 per cent were failures, and in a statistical survey of all localities, failures were placed at 50 per cent. Yet Dr. Harper reports to us that experienced operators made test fillings for him and that over 90 per cent proved to be leaky. Does not this appear to substantiate the claim of the research committee that amalgam used as a "cheap" filling material is not reliable?

But we have a more definite statement from the essayist on this point of amalgam as a cheap filling. Later in his paper he says, "The average sized mesio- or disto-occlusal cavity filled with a medium- or slow-setting alloy will require as much of the operator's time as would be taken when restored with a gold inlay. If this be true, how can we justly charge a reduced fee for our amalgam service?" Such words from an amalgam advocate fully absolves me against the charge of being an amalgam opponent.

I said a few moments ago that there were certain facts brought out in last year's research which were significant. One important fact was that only a very small number of amalgam fillings showed evidence of having been polished, the percentage reported in my own finding being only 9 per cent. As this was based upon an examination of all surfaces, and as of those polished by far the greater number were in occlusal cavities, it follows that on the approximal surfaces, where polishing as a protection against recurrence of decay is most needed, real polishing is seldom accomplished. Indeed, the only approximal fillings that I found absolutely polished were in cavities that did not extend to the gingival margin, and in teeth where it was evident from the stains at the gingival area that no adjacent tooth had been present.

After the presentation of this report, one of our best amalgam operators suggested that amalgam packed against a perfectly smooth matrix would result in a surface sufficiently smooth for all practical purposes. Since hearing this suggestion I have experimented with it, and while I have not used all the amalgams on the market, I do find that with high grade amalgams this theory is not a safe one.

It is customary, I think, to use a matrix which is removed after the insertion of the filling. In such cases it is manifest that the surface of the matrix would have little if any influence upon the surface of the amalgam after the latter had set. In my experiments, therefore, I followed my own invariable custom of using a continuous band as a matrix, which, being left in place for two or three days, prevents all possible disturbance of the

amalgam during the crystallization period, and should result in the polished surface claimed, if such a result could be had with any matrix method. In all experiments thus far, I find the same granulated surface that would be found were no matrix used. Indeed, the surface which rests against the matrix, if anything, is worse than the surface that is not covered. It appears to me more difficult to get a smooth surface to amalgam by merely packing it against a smooth matrix than can be had where the surface is left exposed and can be ironed down with a burnisher before the patient leaves the chair.

These experiments also brought out another fact, which however was well known to me, and presumably to others, and that is that perfect marginal adaptation cannot be procured with a matrix; or rather such margins will not be sufficiently perfect to render it permissible to leave them as found upon removal of the matrix. Hence, it follows that whether a matrix be used or not, the polishing of the approximal surface is absolutely requisite, and must be done after the amalgam has fully set.

The technique presented by the essayist, which is probably sound, would appear to preclude the use of amalgam entirely in certain cavities where it is very often used. Imagine a cavity in the distal surface below the contact point, and reaching to or below the gingival margin. Dr. Harper tells us that, "We must drive and wedge amalgam against cavity walls to secure pressure-contact." How may this be accomplished in the difficult situation suggested? It does not seem possible. In such situations, however, I have had my best results with the following technique: After preparation of the cavity, which understand, *does not reach the occlusal surface*,[2] I fit a continuous band of very soft and very thin copper, so that when placed over the tooth crown it hugs the tooth tightly and also passes below the gum margin. The matrix is removed and the amalgam inserted and packed as tight as possible. The matrix is then slipped over the tooth and filling, and firm burnishing against the matrix will further compress the amalgam excess oozing out at the occlusal margin of the matrix where a slight space must have been left. This technique, of course, would result in an approximal space and lack of approximal contact, a danger, by the way, common with all methods of using amalgam in approximal surfaces. However, an attempt is made to avoid this. The teeth must be well separated in advance. Then, after using the matrix to produce compression of the approximal filling, the matrix is removed, the margins wiped clean and amalgam is added to full contact with the adjacent tooth. When fully set, the

[2] In cavities that involve both approximal and occlusal surfaces, this band matrix is left in place.

approximal surface is thoroughly polished, without removing sufficient material to destroy the contact point. That is to say, you do this if you know of any method of accomplishing it. Perhaps it is the difficulty of doing this that explains the fact that so few men even attempt it.

I must not make this discussion more lengthy than the essayist's paper, which I might easily do. Let me, however, ask a question and suggest an answer to it.

The essayist truly tells us that in the very situation where a perfect filling is most needed, amalgam cannot be inserted successfully for a reduced fee—that it will require just as much of the operator's time as would a gold inlay. If so, why not a gold inlay? Is the additional expense of the actual gold sufficient to make it worth the patient's while to have amalgam instead of a gold inlay? I think not. Why then, should we ever use amalgam? We should use amalgam in those situations, and under those conditions, where a better filling may be made with amalgam than with any other material. If we would restrict our use of amalgam to these cavities and, these only, then we must learn just which amalgam is the best amalgam, and what is the best technique for using that amalgam. The essayist's paper should be valuable to those who use amalgam in this manner only, as naturally they desire to give their patient the best service possible, be he rich or poor.

In conclusion, I must venture a reply to the essayist's main question. His paper is entitled: "Amalgam failures: where is the fault, in the alloy or in the operator." The fault lies in both. The operator is at fault, using the word operator in a collective sense, as we use the word army. The army of dentists is at fault when it uses amalgam because it uses amalgam mainly for the reason that it must accept a lower fee than if gold were used; or amalgam is used because it seems less work; or because the dentist has too large a practice and he can fill more teeth per day with amalgam than with gold. Amalgam so used, accounts in large part for failures, and this constitutes a degradation to our profession. This causes my protest against amalgam; not any inherent shortcomings in the material itself.

There is a fault, however, in the materials that are sold under the common name of amalgam alloy. Compare the facts with gold. If we use gold foil for filling, regardless of where bought, we know that it is approximately 1000 fine. If we use gold for making an inlay, we know just what we are using. It may be pure gold, it may be alloyed with other metals, but we know exactly what we are using. Is this true with amalgam? It is not. When Dr. Harper asks where is the fault which causes the failure of amalgam fillings, I might well ask him: "What amalgam are you talking

about?" When an amalgam advocate comes before us and tells of the marvelous results that may be obtained with amalgam, does he tell us what amalgam he is talking about? Can all the men in the audience go back to their offices and obtain similar results with the many different "amalgams" which they have in stock?

Where then lies the fault? What have the research workers in the great American Dental Association done for us along these lines? Why do they not investigate this, tell us what amalgams are reliable, and list all others as useless nostrums? Nostrums! That is just what many amalgams are. Quite as much so as our vaunted pyorrhea cures. I thank you.

Dr. Harper (in conclusion): I am sorry Dr. Ottolengui did not attend the clinic that he might have observed the perfection in adaptation and finish of the test fillings made by a proved and correct amalgam technique, which I presented. Time will not permit me to answer all the points discussed. Actual demonstrations require much less time, are more convincing, and, in fact, those that were made were indisputable and covered most of the points raised, to which all that saw them will testify.

Statistics are our best guide, when they are complete, but those presented by Dr. Ottolengui could not be so considered, as compared with records of accurately measured test-work done under irregular methods of procedure and other tests done under standardized operative procedures, by men experienced in the work, with accurate measurements of the results attained. Statistics gathered under definite operating conditions, such as are presented in the correct amalgam technique I have used, afford a very different conclusion as to the usefulness of amalgam and would have left little opportunity for the arguments presented by Dr. Ottolengui. I am sure that the demonstrations I have made at this meeting justify this statement of the possibilities of amalgam, when its manipulative needs are understood and applied as shown, and I am even hopeful that they would have proved convincing to Dr. Ottolengui.

Dr. Ottolengui quotes me, as a reason for condemning the use of amalgam in our effort to render cheaper dental service to those who need it, as follows: "The average sized mesio- or disto-occlusal cavity filled with a medium- or slow-setting alloy will require as much of the operator's time as would be taken when restored with a gold inlay." But he failed to quote the following, with which the above is connected: that with a quick-setting alloy, and the application of the operative procedure I present, the same filling could be inserted and finished in *one-third* of the time. This would indicate that amalgam does present opportunities for the saving of the operator's time as compared with that taken in the use of gold.

Dr. Ottolengui reported that one of our best amalgam operators suggested that amalgam, packed against a perfectly smooth matrix, would result in a sufficiently smooth finish to meet the practical needs. This observation is absolutely correct—another detail demonstrated repeatedly at this meeting, irrespective of the fact that Dr. Ottolengui could not secure satisfactory results by the operative procedure he applied in the test work he did. The work I did was removed from the cavity and matrix *immediately* on completion of the packing of the filling, and was passed to the audience for examination; and the verdict I leave to them—another reason why Dr. Ottolengui should have honored me with his presence during the clinics.

Dr. Ottolengui: But you said it could not be made with amalgam.

Dr. Harper: I said with a medium- or slow-setting amalgam.

Dr. Ottolengui: Am I to understand that you have, or know of, or can tell me of, an amalgam that can set in thirty minutes, where the crystalization and the surface of it will not change? If so, will you tell me the name of it?

Dr. Harper: I said an amalgam sets hard enough for me to work on. I did not say the crystalization was complete at the end of that time. As a matter of fact, it takes many hours, but it hardens enough for me to carve to shape and finish in fifteen to twenty-five minutes. This is another fact that was demonstrated for those in attendance.

I have many notes left that I would like to discuss, but I find that I am already intruding on the time of the succeeding essayist,[3] so trust you will forgive me if I stop now.

[3] Souder: *Journal of Dental Research*, 1927, vii, p. 173 (this issue).

MEASUREMENT AND APPLICATION OF CERTAIN PHYSICAL PROPERTIES OF DENTAL AMALGAM[1]

WILMER SOUDER, PHYSICIST

National Bureau of Standards, Washington, D. C.

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INTRODUCTION

I am pleased to appear before your Society and contribute such information as I am able to give for your consideration, criticism, and application. The field of speculation in dental research is enticing, but I shall attempt to keep away from its influence, and to deal with facts and logical deductions from laboratory data. I am not a dentist and therefore you need not worry about anything I say being a liability to your profession.

[1] Read at a meeting of the First District Dental Society of the State of New York, at the New York Academy of Medicine, December 4, 1925.

AMALGAM INDICATED

There is no difference to me whether all or only one-hundredth of your work is amalgam. I shall give my attention to the subject of amalgam with the assumption that, just now, you are as much interested in amalgam as though there were no other filling material. The superiority of gold or porcelain for certain cases must not be raised in this paper. We start out by assuming amalgam is indicated. Your essay committee made that decision for me several weeks ago. I accepted the topic and have no criticism to offer.

SATISFACTORY MATERIAL

When you ask a dentist what qualities he prefers in a dental amalgam, you often get an indefinite reply. He may say: "Edge strength is all I care for," or "I want a material of zero electromotive force." Perhaps he may name some well known or some antiquated product as an example of his ideal in amalgam. In any event the qualities are seldom such that all operators will agree upon their interpretation. By a trial and error method many men have accidentally found a satisfactory material; satisfactory until some change is introduced or until some enthusiast talks him into using another material. From private conversation I find the idea of a satisfactory material varies with different individuals—50 per cent of the restorations giving service at the end of five years is about the lowest I have found. Manifestly this efficiency would not satisfy any truly professional man. Now five years is a long time to wait for a test or report, especially if there is a possibility of 50 per cent loss in service. The patients who will remain loyal under such conditions should be given medals for implicit confidence.

LABORATORY RATING

The application of laboratory methods for grading alloys has never been accepted by the profession. This statement is very broad, but I feel sure I can prove it to you. Black spent many months developing laboratory instruments for testing these alloys. The instruments and methods have since been improved. Disregarding the improvements, how many of you can truthfully say you use an alloy which

has been tested for compliance with Black's standards, by a non-interested party, using his apparatus, and found to be of superior quality? How many dental schools actually measure or have students measure the physical properties of this important tooth saver, amalgam? How many of you have ever heard of a specification for any dental product except perhaps on gold content of a few solders or alloys, and here gold may not be the element of highest importance? Perhaps I should not omit some of your medical supplies, but after all, are not these rated by the U. S. Pharmacopoea and the committee of medical men rather than by the dental profession? Can you imagine a contractor building a bridge from materials carrying no specified qualities, or worse, carrying false claims on properties? Would you purchase an automobile made by a firm which did not test its steel or alloys before building the machine? Can you imagine a manufacturer risking his reputation by putting out a machine produced from materials of uncharted and unspecified qualities? Would you consent to an operation in a hospital which has no testing laboratory and no specifications for instrument sterilization—where the only reply to criticisms would be: "We have cured a number of cases by our methods, why go to the added trouble and expense?"

I realize the success or failure of an amalgam filling is not so important as the above examples might lead some to think. Theoretically, one is as important as the other. You are interested in the practical side; and for successful advancement and development, the practical and theoretical must harmonize. Such has been the experience of successful research organizations in advancing the standards of output from a manufacturing concern.

Perhaps a plan for testing all amalgams and all techniques on patients, requiring them to report periodically for five or ten years, would be a conclusive method for rating materials. Usually, however, it is possible to accelerate service conditions by properly applied laboratory methods. In many cases there are no questions about the injurious effects of one certain physical property, or the desirability of another. These may be written out as negative or positive requirements. Other data require more careful study under more natural conditions.

SELECTION BY SPECIFICATION

After these requirements are established, we may then interpret physical data in terms of actual service, and thus select the materials in the laboratory without making the office a research clinic, often to the discomfort of both the operator and the patient.

From a large number of replies to a questionnaire mailed by the Bureau of Standards some years ago, there has been crystallized a list of requirements which covers the essentials for an amalgam alloy.

DENTAL AMALGAM SPECIFICATION

Résumé of Important Items

Thorough, smooth amalgamation in 3 minutes.

Susceptible to carving for 15 minutes.—Retain polish after 24 hours.

CHEMICAL COMPOSITION	FLOW
Ag 65 to 70 per cent Cu 3 to 6 per cent Sn 26 " 29 " " Zn 0 " 2 " "	After 3 hours set Not over 5 per cent in 24 hours at 3,550 lbs./sq. in.
ULTIMATE STRENGTH	**DIMENSIONAL CHANGE**
After 5 days Minimum 35,500 lbs./sq. in. (2 to 5 minutes for test)	Not over 0.04 per cent shortening during 24 hours At end of 24 hours must lengthen 0.01 to 0.1 per cent

For details of apparatus and manipulation see Bureau of Standards Technologic Paper No. 157.

(For sale by Superintendent of Documents at 10¢ a copy).

The Bureau has developed instruments and described methods for the proper tests to determine whether or not these essentials are present in an alloy. So far as the United States Government is concerned, the amalgam question is closed. The accompanying specification for all official purchases has been promulgated during the last week.[2] This assures a first quality material. No unfair hardship can come to anyone by the application of this standard. I am pleased to report that a large number of manufacturers favor this move.

[2] See the Appendix for a copy of Federal Specifications Board's specification No. 356, which has been mandatory since March 1, 1926.

INDEPENDENT RATINGS

Ratings of products are now possible at disinterested laboratories. The Armour Institute of Chicago has advised that it is equipped for duplicating methods and tests recommended by the Bureau. The Massachusetts Institute of Technology is willing to arrange for these tests when occasion demands. The profession need meet no difficulties if it is ready to adopt such methods or safeguards. Quite naturally, official purchases for the use of the United States Government should be tested in a governmental laboratory, but to attempt testing for all individuals desiring tests would interfere seriously with the prosecution of researches now in progress. Furthermore, tests or researches made outside and without the coöperation of a society can never be as convincing as those made by members of the society. My report to your society can never carry the weight of a report from tests by your Dr. Vetter, Dr. McCall, or Dr. Dewey. This is well illustrated by the present status of the amalgam specification. Although we kept in close touch with your National Association and forwarded our reports to its officials and to many individual dentists, we were never able to secure the active interest and enthusiastic support in the program, which would have been given if they had spent their own time or money on the program. I say this with no thought or desire to criticise any person or organization. The problem before us to-day is simply to study the properties of amalgams.

WONDERFUL METALLURGICAL PROCESS

The behavior of mercury and the silver alloy in forming a crystalline material is exceptional in one respect: the union will take place at ordinary temperatures. Metallic elements often combine to form a new crystalline alloy, but usually a considerable elevation in temperature is required. The temperature for the union of the elements in the complex gold alloy is in many instances above 1000°C. Nature has provided a wonderful metallurgical process for your art. The molten mercury and the solid alloy combine readily and without the evolution of excessive heat, and the reaction is sufficiently slow to permit a reasonable amount of adaptation before the process reaches complete solidification. I call the process wonderful because of the

time interval over which the transformation takes place, and because of the degree of rigidity or strength developed in the final product. Of course, we realize this final strength and the optimum time interval for the reaction have been developed by numerous experiments. Regardless of the properties of a simple silver-mercury mixture, we must abandon the mixture as not practical because of the rapidity of the transformation. Tin and mercury would be eliminated by the weakness of the mixture, copper and mercury by the difficulty in getting it to mix, or, if mixed by methods requiring greater care, by its discoloration.

SATISFACTORY ALLOY

Experience has pointed to an alloy of approximately 68 per cent silver, 27 per cent tin, 5 per cent copper (and sometimes 1 per cent zinc at the expense of one or more of the other three elements). This alloy if properly melted, cooled, and cut into particles of $\frac{1}{100}$ to $\frac{1}{150}$ inch dimensions and annealed, will rate as a very respectable product. Thus far, there appear to be no reasons for dissatisfaction, and the question arises, "Why test this material?" Laboratory analyses sometimes show wide variations from the above formula, or the inclusion of other elements as impurities. It has also been found that alloys of identical composition behave differently. You may verify this by heating some alloy particles to 200 or 250°C. and holding at that temperature for a few minutes. Alloy treated in such a manner will amalgamate with difficulty and will have a sandy feel or texture when amalgamated.

I should not overlook a grade of alloys made from 45 to 55 per cent silver with tin and copper. Such compositions possess a number of desirable features, but are not so flexible or safe as the others. For example, in the effort to secure strength or hardness, so much copper may be added that the amalgam will not hold all its mercury permanently, or the alloy may discolor more than regular compositions. The difference in actual cost for an individual restoration does not justify your taking chances.

PERFORMANCE STANDARD

I suppose the question in your mind at this minute is: Why not specify a composition of 67 to 69 silver, 26 to 29 tin, 4 to 6 copper,

and 0 to 2 zinc? With a uniform process of manufacture this would be satisfactory, but all people do not use the same care in their plant, and since it is not practicable to depend upon a production standard, the remaining solution is to set up a performance standard. Such a standard was prepared by this Bureau some years ago after a lengthy study of manipulations, materials, and results obtained. The coöperation and advice of a large number of your profession was of value in preparing this standard. From the data secured and from laboratory verification, the amalgam question for the U. S. Government has been reduced to a selection of materials on the basis of laboratory performance. These are outlined in a Federal Specification which should appear in your professional journal at an early date. (See the Appendix.)

CHEMICAL TESTS

The chemical composition which appears to give most lasting and permanent results establishes itself around the limits mentioned above, and is so specified. Often we hear rumors of a new composition which is alleged to surpass all other materials, but such marvels seldom supplant the old values. Manifestly the easiest way to establish compliance with the above formula is by a quantitative chemical analysis. This will present no difficulty to any member of your society who cares to make a determination of these elements.

DIMENSIONAL CHANGES

The length or dimensional changes occurring during amalgamation are very vital to the success of the restoration. This subject has received and is now receiving some horrible misrepresentations. Conclusions are jumped at without proper consideration of fundamentals. Let me give you one example. Amalgams are packed in solid containers of glass, steel or similar material, and the adaptation of the material to the rigid block of steel or glass is taken as a sufficient test for approval. It may appear to be a tedious process to prove the fallacy of such tests but it is worth your serious consideration. The facts are these:

1. Amalgam has a rather high coefficient of thermal expansion, 25 $\times 10^{-6}$ per degree Centigrade (this is practically twice the expansion of steel and three times the value of glass).

2. All good amalgams expand upon crystallization without necessarily changing temperature. In many of these the expansion is somewhat irregular, in fact, there may appear a slight shrinkage for a few minutes after amalgamation, followed by an expansion of perhaps 0.07 to 0.09 per cent and this in turn by a contraction of 0.01 to 0.05 per cent, leaving the completely solidified amalgam say 0.05 per cent larger than when adapted to the cavity.

3. Amalgam, if compressed in a rigid cavity, such as steel, will flow or move to a new dimension, if any one surface is free to move.

These facts assembled, give the following result for the conditions assumed. Amalgam fitting perfectly in a rigid steel cavity will be compressed, if the temperature is elevated, as the steel does not expand fast enough to permit full expansion of the amalgam. The amalgam may adjust itself by flowing as stated above, of course still fitting the cavity snugly. But, when both amalgam and steel cool, the amalgam pulls away from the steel and shows a cavity or lack of adaptation which, if not carefully interpreted, will cause you to reject a good alloy. The resiliency of tooth material may enable it to absorb the excess expansion of amalgam and prevent the above error, even though the temperature expansion of tooth substances is only one-third that of amalgam. I do not have to argue, I am sure, to convince you that a tooth cavity of normal dentine with walls $\frac{1}{16}$ to $\frac{1}{8}$ inch thick and one side cut away perhaps, is not as rigid as a solid steel or glass block with walls many times as thick. A steel or glass cylinder with walls approximating tooth walls in shape and thickness, and then slotted would, perhaps, more nearly simulate mouth conditions.

In a similar manner, excess mercury placed at the bottom of a steel or glass test-form will prevent air passing for a few hours. This can be accomplished by light packing of amalgam containing excess mercury or stranger still, by tapping the glass or steel form on the table. The tapping segregates the fluid mercury of high density to the bottom of the cavity and leaves a relatively dry amalgam on top. If you approve leaving free mercury at the base of a filling and can devise a way to jar the material into the cavity, I shall have to give further attention and tests to such technique. I have taken celluloid and cut cavities, similar to normal conditions for wall thickness, etc., and

secured entirely different results from those made in steel. Celluloid is not a satisfactory duplication of tooth dentine, but it shows the value of the resiliency effect which you hope to capitalize in your amalgam restorations. Should you request a value for the ultimate compressional strength of human dentine, I can suggest the value of 30,000 pounds per square inch. I say suggest rather than establish because of the uncertainties in my tests. You may change it to 25,000 or 35,000 if you wish.

The 0.07 to 0.09 per cent setting expansion mentioned above, followed by the 0.01 to 0.05 per cent contraction, could indicate failure in the steel cavity, as the new dimensions forced by the steel at the instant of 0.09 per cent expansion would shorten when the later contraction of 0.05 per cent appeared—and again you might reject a good alloy, if you forgot about the thin walls and elastic properties of the tooth.

A final and worse possibility will be illustrated by the following example, and will explain how a shrinking amalgam may appear to be perfect under such tests if excess mercury is not removed. If you fill a tube with dry powder you will usually be able to force air past the powder particles even though the interspaces are exceedingly narrow. When you put the tube and powder into a liquid which wets them, the liquid will quickly force itself in by capillary attraction and no further air will pass until enormous pressures are applied or until the interspaces are markedly enlarged. You get the application without further elaboration.

TESTING DIMENSIONAL CHANGES

After this slight divergence, may I state what I believe to be a true test for constancy of dimension? Prepare the test specimen in a rigid mold if you wish, but remove it at the instant it is completed and never afterward apply a restraining force. This will show what it wants to do during the completion of crystallization and what it does do, except for a slight modification, perhaps by the resistance of the tooth walls. There is no instrument more satisfactory for this test than the interferometer displayed on the table before you. In a few minutes I shall show you some curves which display the unrestrained changes of dimension for different amalgams and different

techniques. You will be surprised when I tell you some of the materials show decided shrinkage. I am not able to explain how it is possible to make satisfactory fillings from them. Theory says a material of slight expansion upon setting should be better for all work, but it is difficult to convince all members of this decision. "Safety plus," certainly demands the expanding material to lock itself securely in the cavity.

FLOW OF AMALGAM

I have mentioned the yielding of an amalgam when compressed. This yielding is permanent if carried beyond a certain limit and will be called flow. The exact amount of this flow will vary for the different amalgams, and the only solution of the difficulty is to select a material of minimum flow. The disappearance of contact points, the bulging of a filling over the margins and the distortions of a filling in a cavity are proof of the existence of this menace of weak alloys. The most conclusive proof to me of this fact is my own experience with some twelve or fifteen amalgam restorations. I am sure these were placed with exceptional care. The cavities were not difficult to prepare. Matrices were used and in many cases these were wedged or tied to the tooth. The contacts were excellent at the time the work was completed. There were no appreciable overhanging ledges. But after two or three years the contacts disappeared and margins forced out so that a silk floss or pick would hang at the gingival. We discussed the situation and decided that recurrent decay had rotated the filling. This explanation appeared satisfactory at that time. Fortunately, during my school days at the University of Chicago, about twelve years ago, I had some work done by a man who had been a pupil of Black. He explained a number of things about Black's lectures and laboratory experiments, which I am sorry to admit I did not appreciate at the time. I showed him some of the failing contacts and, as I remember, he explained them as a result of a faulty cavity preparation and a poor alloy. I do know that he cut his cavities with a retaining or reinforcing ledge and that he said he was using an alloy approved by Black. I am proud to say his work is still giving satisfaction. The least I can say is, "There is a difference." When we recognize and chart this difference, the problem is solved. Last

month I received a letter from a man in a western state inquiring how a filling once properly carved and finished could later bulge out at the base of the cavity. The constant tapping of an opposing cusp in the softer grade of amalgam easily hammers or batters the material until it moves away at some unprotected margin.

AMALGAM AND STEEL

We may have been led to believe that amalgam is similar to steel in its characteristics, which is true perhaps in one respect, but in its rigidity or resistance to flow it is very different. Amalgam will flow when subjected to only one-tenth of its crushing load. The usual method of stating this as a safety factor in terms of its ultimate compressive strength would be to say that a safety factor of 10 is not large enough; whereas for steel this would be extremely conservative.

Another way to express it is to say: the modulus of elasticity of amalgam is 1,500,000, only one-twentieth that of steel which is usually rated as 30,000,000. On a sudden application of stress it is possible to show a crushing strength equal to steel, but for a constantly applied stress, such as is present at adjacent tooth contact or occlusal contacts from opposing teeth, we must apply data from constant stress tests over several hours. With all this, amalgam is strong enough for many restorations, and if properly respected will give satisfactory service.

ULTIMATE COMPRESSIVE STRENGTH

The ultimate compressive strength is readily tested, and its application is not difficult to interpret, but do not allow a value of 40,000 pounds per square inch strength to deceive you on the strength of an exposed thin margin or on the ability to withstand the constant shocks from an opposing cusp, for 40,000 pounds per square inch is only 100 pounds per $\frac{1}{10}$ inch square. Furthermore, we have just discussed the universal defect of flow at one-tenth the crushing load; hence, the flow danger value is to be based on only 4,000 pounds per square inch or 10 pounds for a $\frac{1}{10}$ inch square cusp. When we consider the above limitations of our material we are forced to conclude that amalgam is not proof against failures; that care must be exercised

in designing the structure and that an attempt to build the structure without incorporating what the engineer calls a safety factor may lead to disappointments.

TESTED ALLOYS DESIRABLE

As soon as you demand tested alloys you may begin to check up on the accuracy of your technique. When I say tested alloys I mean alloys tested or rated by an independent properly equipped non-interested laboratory. For impartiality you deserve this privilege. The technical schools and dental college laboratories have had ample time to equip themselves for making the tests by approved methods and in approved apparatus. Some of them have done so. Many have not. The future advancement in quality of alloy supplied to you is largely in your own hands.

I have outlined a few of the important items which a superior alloy possesses. The methods of making these measurements are described in detail in Bureau of Standards Technologic Paper No. 157; also in *Dental Cosmos*, March 1920. A few pieces of the equipment have been arranged on the table for your inspection. I want to describe them very briefly at the close of this paper and then show you some results which have been recorded on lantern slides.

REASONABLE TECHNIQUE FOR TEST SPECIMENS

It would not be fair to close this paper without a word regarding the necessity for constructing test specimens by a technique as nearly as possible like the proposed technique to be used in making restorations. I have tried special methods but I do not care to draw conclusions from special mixes or special packing, wherein conditions are introduced which it is not possible to duplicate in actual practice. You may rest assured all the data I give you are applicable to actual conditions as you will meet them. The techniques are those used in practice. The test specimens are packed in cavities not greatly different in size from those you pack. The walls are stepped. The top or finishing amalgam is built above the cavity, then carved away to remove excess mercury. Such data are safe for application to the conditions you meet, for your work is essentially the same as that in

the laboratory. You can pack your cavity; you can conduct all your manipulative activities connected with the work just as was done in the laboratory.

You have noticed my avoidance of the metallurgical aspects of this problem. There are two reasons: my lack of ability to advance a theory explaining all parts of the process, and the reluctance even of first rate metallurgists to attempt a complete explanation of all relations in a four or five component system. Many speculations could be made in this field, speculations which could not be disproven readily, but I prefer to leave that to others. Expert metallurgists are cautious in this field. That is sufficient warning for me to keep quiet on the subject. Physical properties do not depend upon the correctness or falsity of a metallurgical theory.

I think I may add for the information of those contemplating an installation of testing equipment that the instruments shown are available as stock material. The flow micrometer is from E. J. Cady and Company of Chicago. The interferometer and viewing device are loaned by Keuffel and Esser Company of this city. This statement of a source for these instruments must not be considered as an advertisement or favor to anyone. As soon as other firms duplicate the above, or design similar instruments I shall be pleased to add their names to the list. I assure you my only interest is in helping you to secure a product tested by a non-interested laboratory; for, when you secure such you will be able to rate your own personal equation and the success of your favorite technique.

CONCLUSIONS

If I were to attempt a summary of this paper it would be a plea for standardization for the following reasons:

(a) This will assure your getting a first quality material.

(b) With the proper technique your work will be as satisfactory as it is possible to make it.

(c) Manufacturers will be protected for their care in supplying a superior product.

(d) The public will receive the maximum return for the fee paid.

Appendix

UNITED STATES GOVERNMENT MASTER SPECIFICATION FOR DENTAL AMALGAM ALLOY

Federal Specifications Board: Specification No. 356

This specification was officially promulgated by the Federal Specifications Board on November 30, 1925, for the use of the Departments and Independent Establishments of the Government in the purchase of dental amalgam alloy. The latest date on which the technical requirements of this specification shall become mandatory for all Departments and Independent Establishments of the Government, is March 1, 1926. They may be put into effect however, at any earlier date, after promulgation.

UNITED STATES GOVERNMENT MASTER SPECIFICATION FOR DENTAL AMALGAM ALLOY

I. *General specifications.* There are no general specifications applicable to this specification.

II. *Types.* The following types shall be furnished, as ordered:

Type A. Shavings.

Type B. Filings.

III. *Material.* The comminuted alloy shall be free of foreign materials and shall be uniform.

IV. *General requirements.* Amalgams shall possess the following features, known as satisfactory working qualities:

1. Thorough amalgamation in three minutes.
2. Absence of granular or sandy consistency when amalgamated.
3. Susceptibility to carving for at least fifteen minutes after amalgamation.
4. Susceptibility to receiving and retaining a polish twenty-four hours after amalgamation.

V. *Detail requirements.* 1. Chemical Composition.—The chemical composition shall be within the following limits:

Silver	65 to 70 per cent
Tin	26 to 29 per cent
Copper	3 to 6 per cent
Zinc	0 to 2 per cent

2. Ultimate compressive strength.—The average ultimate compressive strength values of three or more tests shall not fall below 2,500 kilograms per square centimeter (approximately 35,500 pounds per square inch).

3. Flow.—Specimens subjected to a constant pressure of 250 kilograms per square centimeter (approximately 3,550 pounds per square inch) shall not show more than 5 per cent flow (i. e., more than 5 per cent shortening in length of specimen) in a period of twenty-four hours.

4. Setting Changes.—Twenty-four hours after amalgamation the length shall have increased between one and ten microns per centimeter. If at any time during the test a contraction of more than four microns per centimeter is detected, the alloy shall be rejected.

VI. *Method of sampling and tests.* 1. At least 1 oz. shall be taken at random from every 500 oz. or fraction thereof for test at time of delivery.

2. Ultimate compressive strength.—Specimens shall be cylinders 6 mm. in diameter and 12 mm. long. These shall be prepared by condensing the amalgam into a cavity of these dimensions in a rigid block, using a reasonable technique (approximately that given in the sheet of instructions accompanying the alloy).

The ends of the cylinder shall be surfaced plane at right angles to the axis. Strength tests shall be made five days after condensing and the actual time consumed in applying the load shall not be over five minutes nor under two minutes. Tests shall be made at temperatures between 20 and 25° C.

3. Flow.—Specimens shall be cylinders 4 mm. in diameter and 8 mm. long, and shall be prepared in the same manner as those for crushing. Three hours after condensing, the specimen shall be subjected to a constant pressure of 250 kilograms per square centimeter (approximately 3,550 pounds per square inch). During this test the specimen shall be maintained at a temperature between 20 and 25° C.

4. Setting changes.—Specimens shall be prepared by condensing into a cavity or matrix. These shall be removed as soon as condensation is completed and shall not be subject to restraint during the test. Measurements shall begin fifteen minutes after amalgamation. (Time spent in mulling and condensing to be included as a part of the fifteen minutes.)

VII. *Packing.* 1. Alloy shall be packed in moisture resisting containers and in quantities of one or five ounces as may be specified.

2. Instructions for manipulation must accompany each package.

VIII. *Notes.* 1. The foregoing specification is for the so-called "silver" amalgams which are to be used for restorations in the mouth.

2. Instruments and methods suitable for measuring the physical properties of alloys are described in Bureau of Standards Technologic Paper No. 157 and in the *Dental Cosmos*, March 1920, pp. 305–335. It is not desired to limit the tests to the types of apparatus mentioned therein; on the contrary, any approved device, the accuracy of which is proven equal to those named, may be used.

3. Bids shall be in terms of ounces, Troy (31.1 grams).

THE ORIGIN AND EVOLUTION OF THE HUMAN DENTITION

A Palæontological Review

BY

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Illustrated with 15 plates and 353 figures
6 x 9 Cloth, gold stamped 548 pages
Detailed Index Full Bibliography

The Origin and Evolution of the Human Dentition is a masterly review of the palæontological facts relating to the origin and evolution of the teeth in man, by one of the best informed investigators in this field. The book presents a complete summary of the main facts in the palæontological record on the origin and evolution of human dentition; and will be universally regarded as the most notable and successful effort to epitomize this information, to reveal its full evolutional import, and to suggest its practical significance. This review is a great fund of important facts and opinions in dental science, and must be STUDIED, particularly in close comparison of the text with the many exceptional illustrations, to be fully appreciated

The author discusses broadly various important phases of human evolution in general.

Of special interest to dentists, physicians, palæontologists, odontologists, morphologists, and students of evolution and inheritance.

CONTENTS

Part I. Traces the stages of ascent from the Silurian fishes to the mammals of the Age of Reptiles.

Part II. Covers the stages from the Paleocene placental mammals to the lower primates.

Part III. Describes Nature's earlier experiments in evolving large-eyed and short-jawed primates.

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